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CEL-1 LIGHTING COMPUTER PROGRAM – USER'S GUIDE

September 1981

An Investigation Conducted by
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20. ABSTRACT (Continue on reverse side if necessary and identify by block number) The Conservation of Electric Lighting Computer Program, Version 1.0 (CEL-1), aids the illumination engineer in designing energy efficient rooms. CEL-1 contains a design synthesizer which selects from among a set of user specified luminaire locations the subset which best satisfies user's design criteria. Lighting metrics which may be calculated include		

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illuminance, luminance, equivalent sphere illuminance, and visual comfort probability. Energy profiles resulting from lighting controls which respond to daylight can be evaluated using CEL-1. This user's guide is divided into seven sections:

1. Overview of Computer Concepts
2. Basic Structure of CEL-1
3. Application and Examples
4. Comprehensive Reference of Input Data Required
5. Auxiliary Files
6. Using CEL-1 from Batch Terminal
7. Using CEL-1 from Interactive Terminal

TABLE OF CONTENTS

TABLE OF CONTENTS (Cont'd)

TABLE OF CONTENTS (Cont'd)

LIST OF FIGURES

LIST OF FIGURES (Cont'd)

LIST OF FIGURES (Cont'd)

LIST OF FIGURES (Cont'd)

INTRODUCTION

This manual is organized into the following sections:

Section I - Overview of computer concepts, access to computer facilities, modes of running CEL-1 programs.

Section II - Brief descriptions of the program structure of CEL-1 and of the modular block structure which characterizes the input data deck.

Section III - Descriptions and examples of the applications for which CEL-1 is intended. This section begins with the simplest use to which CEL-1 will be put and then attempts to walk the user through increasingly sophisticated applications. The focus of this section is on familiarizing the user with the numbers and keywords which constitute the input data to CEL-1 programs.

Section IV - Detailed reference section. This section describes in exhaustive detail each parameter permitted in the CEL-1 input data deck. In contrast to the informal, friendly tone of section II, section III is the formal description of all facilities available in CEL-1.

Section V - Auxiliary files. This section discusses the additional data files (e.g., photometric candela data) which must be present for CEL-1 to function properly.

Section VI - Executing the CEL-1 programs on a remote batch terminal. This section shows how to execute CEL-1 programs on CYBERNET services NOS computing facility. While Sections III and IV deal with the input data deck (numbers and keywords), this section concentrates on the NOS control cards which precede the data deck.

Section VII - Interactive features. This section discusses the programs available to the user who has access to an interactive terminal. These interactive programs facilitate the construction of the input deck and submission of the job for execution.

No section of this guide stands on its own; the user is strongly advised to read the entire manual from cover to cover before using the programs. However, the user who is in a hurry might get by with Sections III and VI (III and VII if using an interactive terminal).

SECTION I

Overview of computer concepts and access.

1.1 Computer concepts

The CEL-1 package consists of sophisticated scientific computer programs to be used on the NOS (Network Operating System) computer facilities of CDC's CYBERNET services. To use this manual, the user should understand the following terms as they will be employed in this manual:

Computer - Refers to the electronic "brain" (arithmetic and decision-making capability) and "memory" (where a program and its data are stored while the program is executing).

Peripherals - Refers to any device which is used to bring data into or out of the computer's memory. In this manual, the peripherals of interest are disc storage units, printers, card readers, and interactive terminals.

Disc Storage - A magnetic data storage medium indispensable to CEL-1 and most other computer applications. The salient characteristics of disc storage are ability to access any data stored on the device quickly and volume of storage available.

Central Site - The physical location of the computer and its on-site peripherals such as disc storage, line printers, card readers, etc.

Remote Batch Terminal (also known as an RJE terminal) - Usually a card reader / line printer combination which may be connected to the computer via some arrangement of communication lines. This station is used in the same manner as a card reader and line printer at the central site. The reader and printer at a remote batch terminal are usually fairly high-speed devices.

Interactive terminal - A keyboard/printer combination intended for communicating with the central site computer via voice-grade telephone lines. In contrast to the reader/printer at a remote batch terminal, interactive terminals are normally fairly slow devices, although their transmission speeds may be as fast as 120 characters per second.

File - This term refers to a collection of logically related data. A disc storage device, for example, may contain hundreds or thousands of uniquely-named files, in much the same vein that a typical business's filing cabinet contains many uniquely-named file folders. A "permanent disc file" is a file which resides on a disc storage device until the user explicitly causes it to be erased. In this manual, the term "file" will usually mean a permanent disc file.

1.2 Accessing and Using the Computer

The CEL-1 programs may be accessed and used in one of these two ways:

1.2.1 Batch Mode

In batch mode, the user connects to the computer via a remote batch terminal and feeds a deck of punched cards (called a "job") through the terminal's card reader. Once the cards have been read in and the computer has acknowledged receipt of the job, the user may disconnect from the computer. At a later time (after the job has had time to execute), the batch terminal may be reconnected to the computer and the CEL-1 output listed on the line printer. Optionally, the user may request (via an appropriate card in the job deck) that his output be listed at the central site and physically delivered to him.

The card deck which is fed into the reader contains the following information:

a) NOS accounting information (the user's access code so that CDC knows who to bill for the computer time).

b) other NOS control statements which tell the computer what program the user wishes to run and what permanent disc files he needs, where his output is to be printed, etc.

c) CEL-1 input data values. These are the numbers and keywords which tell the CEL-1 program what to calculate. For example, the CEL-1 program must always know the room reflectances -- these values are specified on one of the punched cards.

Sections III and IV of this manual deal with the parameters which go on the cards described in c). These cards may be referred to as the "CEL-1 input data deck", "input data deck", "input data", or "data deck". Section VI shows the exact deck structure required - i.e., how to integrate a), b), and c) to obtain a valid execution stream.

1.2.2 Interactive Mode

In this mode, the user connects to the computer via an interactive terminal. He then prepares and saves as a permanent disc file the CEL-1 input data (described in 1c above). He may do this in one of 2 ways:

i) Using the NOS text editing capability.

ii) Using the preprocessor. The preprocessor is an interactive program which allows the user to construct the CEL-1 input data deck via a question-and-answer sequence.

With the preprocessor, the user need not be familiar with NOS text editing procedures.

Following preparation of the input data, the user may then initiate the execution of the CEL-1 program he wishes to run. In interactive mode, the user has 3 choices for the disposition of his output:

i) He may route it to a remote batch terminal which he specifies.

ii) He may request that his output be printed at the central site and subsequently physically delivered to him.

iii) He may have the output saved on a permanent disc file which he may subsequently list at his interactive terminal.

Section VII describes in detail the use of an interactive terminal to run the CEL-1 programs.

SECTION II

Basic Structure of CEL-1

2.1 Programs

The CEL-1 package consists of approximately twenty separate programs. A particular job will involve a particular subset of these programs. For example, the program which draws character contour plots will not be executed if the user does not request contour plots as part of his output.

This program structure of the CEL-1 package is transparent to the user. I.e., the user need not be concerned with the programs which are executed; the proper subset will be invoked automatically, based on the contents of the user's input data deck. The user never calls for a particular program by name; rather, his input data deck results in the selection of the necessary programs by the CEL-1 control structure. Therefore, the user's task is to properly identify (in the input data deck) the functions CEL-1 is to perform -- he need not worry about which programs are going to be executed.

2.2 Input Data Deck Block Structure

The input data deck for CEL-1 consists of several "blocks" of information. Each block describes some particular aspect of the lighting application under consideration. Each block is headed by a keyword which identifies the information contained in the block. For example, luminaire dimensions and locations are given in the LUMINAIRES block.

In general, each block consists of the heading keyword (first card in the block) which names the block, followed by one or more cards of data values. These data values may be numbers, filenames, or keywords. The block structure is recursive, in that a block may contain one or more sub-blocks, each of which possesses the same structure as a block itself (i.e., naming keyword followed by one or more data cards). A general description of each block is given below:

ROOM block

This block is always included in the data deck. It contains:

a) Five cards of text for identifying the printed output.
b) Specification of the units to be used (English or metric).
c) Room dimensions and discretization parameters.
d) Room surface reflectances.

INSERTS block

This block is optional and is included to define areas on room surfaces which have reflectance different from that of the underlying surface; e.g., doors, murals, etc.

TASK block

The TASK block defines the locations of the target points within the room, and the observer viewing directions, if any. This block must always be included in the data deck.

SENSORS block
This block defines the locations of sensors at which illuminance is to be calculated. Sensors are used in conjunction with daylight computations and may be located outside the room, on the ceiling, or at the task plane.

FENESTRATION block
The FENESTRATION block contains the specifications for room surface openings which admit daylight into the room. The block is composed of sub-blocks which define each different kind of fenestration permitted: WINDOW, CLERESTORY, SAWTOOTH, and SKYLIGHT. In turn, the WINDOW sub-block may be immediately followed by these sub-blocks which define window refinements: SHADE, DRAPE, BLINDS, SHELF, BARRIERS.

The sub-blocks BUILDING and GROUND are always present in the FENESTRATION block.

FURNITURE block.
The FURNITURE block specifies the locations of any objects (partitions, file cabinets, desks, etc.) in the room.

PROFILE block.
This block gives the parameters necessary for the computation of an energy profile: latitude and longitude of the site, time zone information, weather station ID for cloud condition data, room occupancy factors.

ANALYSIS block.
For daylight computations, either the ANALYSIS block or the PROFILE block are present in the job stream -- never both. The ANALYSIS block supplies the necessary inputs when an energy profile is not desired.

LUMINAIRES block.
This block specifies the locations and orientations of the luminaires to be used in the job. The luminaire dimensions and an indicator of what photometric data is to be used are also given.

DIMMING block.
This block is used when computing an energy profile. It contains the dimming strategy to be used and also tells which luminaires are to be always off and/or on. The block may also be used in "analysis" mode to turn certain luminaires off.

DESIGN block.
The DESIGN block is used in lieu of the LUMINAIRES block when employing the design synthesizer. The block is similar to

the LUMINAIRES block, except that it contains all possible luminaire locations. The program selects the final luminaire locations from the user-supplied set.

CALCULATE block.

This block specifies which lighting metrics are to be computed -- ESI, footcandles, etc.

SECTION III

CEL-1 and Lighting Applications

3.1 Basic Calculations

Perhaps the simplest use of the CEL-1 package is for computing any of several lighting metrics when the lighting layout is fixed and no furniture or daylight are to be considered. Refer to the room shown in Figure 1a.

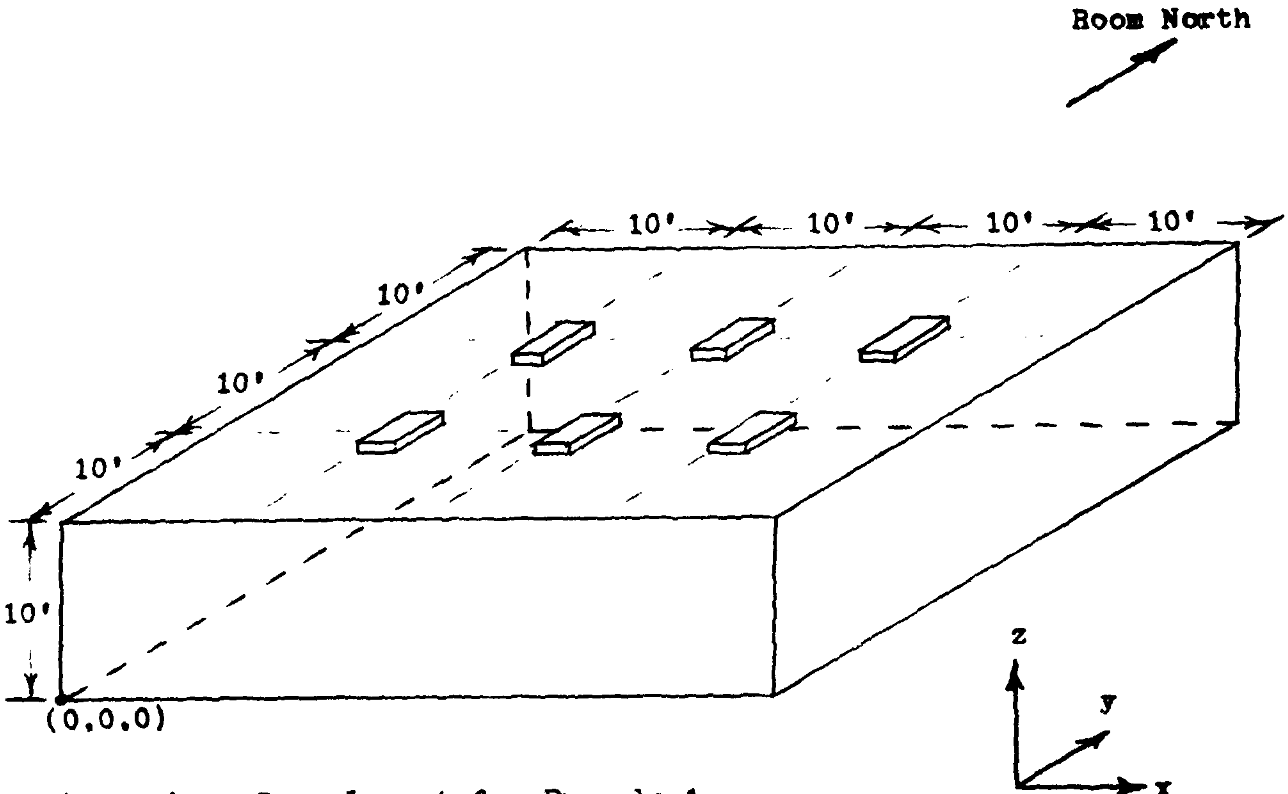

Figure 1a: Room Layout for Example 1

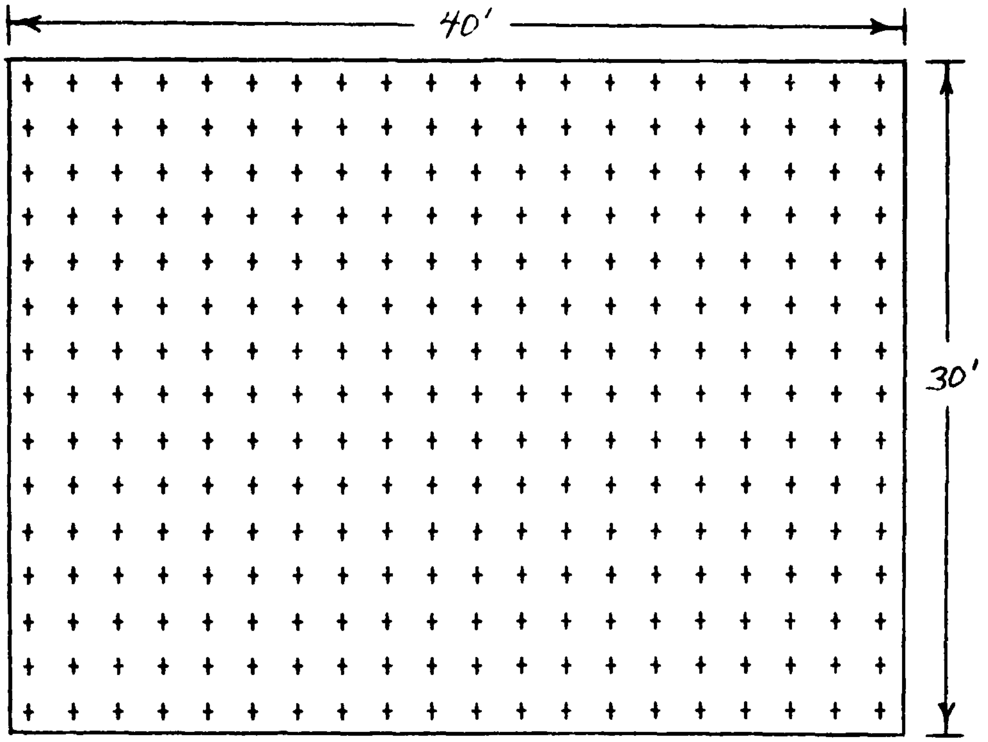

Figure 1b: The grid of target points spans the room uniformly at 2' intervals in each direction.

Figure 1a depicts a 40' x 30' x 10' room with 6 fluorescent luminaires on 10' x 10' centers. Suppose we wish to compute ESI and Horizontal fc (no body shadow) on a work plane 2.5' above the floor. Beginning 1' in from each corner, we want to compute values on this plane every 2' in each direction. This yields a rectangular grid of target points shown in Figure 1b. In addition, we want to compute VCP 4' above the floor over this grid.

The CEL-1 input deck for this application would be:

```
ROOM
EXAMPLE 1 -  40' X 30' X 10' ROOM
REFLECTANCES:  (WALLS = 50%, FLOOR = 20%,  CEILING = 80%)
SIX 2-LAMP FLUORESCENT LUMINAIRES  (PHOTOMETRIC FILE 'HB57'),
   3150 LUMENS PER LAMP.
NO FURNITURE OR DAYLIGHT.  CALCULATIONS:  ESI, HORIZ FC, VCP
  1  1
40 20  30 15  10 5
.5 .5 .5 .5 .2 .8
TASK
UNKNOWN
 20 15  1 39  1 29  2.5  4.0
   4
0. 90. 180. -90.
```

```
LUMINAIRES
HB57
6300.  .82
1.833 3.833 0.5  92
0 0 0 0
  6
1  10 10 9.5  0 0 0
2  20 10 9.5  0 0 0
3  30 10 9.5  0 0 0
4  10 20 9.5  0 0 0
5  20 20 9.5  0 0 0
6  30 20 9.5  0 0 0
CALCULATE
ESI HOR VCP
P25B
P25T
```

The following discussion describes each card in the data deck:

ROOM

This is the card which names the ROOM block.

EXAMPLE 1 - 40' X 30' X 10' ROOM
REFLECTANCES: (WALLS = 50%, FLOOR = 20%, CEILING = 80%)
SIX 2-LAMP FLUORESCENT LUMINAIRES (PHOTOMETRIC FILE 'HB57'),
3150 LUMENS PER LAMP.
NO FURNITURE OR DAYLIGHT. CALCULATIONS: ESI, HORIZ FC, VCP

These 5 cards are for identification purposes only and have no influence on the computations. The 5 cards may contain any text the user desires (max 80 characters per card). The text on the cards is printed with the CEL-1 output listing and helps the user identify his output. Note that any or all of the cards may be left completely blank.

1 1

This card defines the units which are to be used in the calculations. Two integer values must appear on the card, and each integer must be either 1 or 2. The first value specifies the input units:

1 - English units. All coordinates and dimensions are given in feet.
2 - Metric unit. All coordinates and dimensions are given in meters.

The second value on the card specifies the units to be used in printing the output:

1 - English units. Illuminance values will be printed in footcandles; luminance values will be printed in footlamberts.

2 - Metric units. Illuminance values will be printed in lux; luminance values will be printed in candelas per square meter.

40 20 30 15 10 5

This card specifies the room dimensions and the # of zones into which each room dimension is to be divided in order to compute the effect of the luminous room surfaces at the target points (I.e., the indirect component).

40 20 specifies that the width (east-width measure) of the room is 40' and that the east-west dimension of any room surface is to be divided into 20 sections (each 2' across) for the indirect component calculation.

30 15 specifies that the length (north-south measure) of the room is 30' and that the north-south dimension of any room surface is to be divided into 15 sections (each 2' across) for the the indirect component calculation.

10 5 specifies that the height (floor to ceiling) of the room is 10' and the up-down dimension of any wall is to be divided into 5 sections (each 2' high) for the indirect component calculation.

.5 .5 .5 .5 .2 .8

This card specifies the reflectance of each room surface. In order, the six values give the reflectances of:

1 - west wall
2 - north wall
3 - east wall
4 - south wall
5 - floor
6 - ceiling

TASK

This card names the TASK block.

UNKNOWN

This keyword specifies that the few cards to follow define a rectangular grid of target points at which lighting metrics are to be calculated. This keyword phrase (and any other keyword phrase, for that matter) must always appear on the card beginning in column 1.

20 15 1 39 1 29 2.5 4.0

This card defines the rectangular grid of target points as follows:

20 - 20 columns of points (a column has constant x-coordinate

-- i.e., a column "runs" north-south)

15 - 15 rows of points (a row has constant y-coordinate -- i.e., a row "runs" east-west)

1 39 - the x-coordinates, respectively, of the leftmost and rightmost columns of target points.

1 29 - The y-coordinates, respectively, of the bottom and top rows of target points.

2.5 - the height above the floor of the target points.

4.0 - the height above the floor at which VCP is to be calculated (generally this will be the eye height of an observer who is seated). Note that a real number must always be coded here, regardless of whether or not VCP is being calculated. If VCP is not computed, the value is read in off the card but is subsequently ignored.

4

This card specifies how many viewing directions are to be used in the calculations. The value must be an integer in the range 0 - 4.

0. 90. 180. -90.

These four angles specify the viewing directions in degrees. There must be the same number of angles on this card as the number of viewing directions specified on the previous card. If zero viewing directions were specified (i.e., only horizontal fc are being calculated), this card must be omitted from the deck. Any angle is permitted as a viewing direction; 0 is room north, 90 is room east, 180 is room south -90 is room west. E.g., northwest would be -45 degrees. In general, if A is any angle, A may be used interchangeably with A + 360. For example, 270 specifies the same viewing direction as -90. However, it is recommended that the user adopt the convention that all angles will be specified in the range -180 to 180 degrees.

LUMINAIRES

This keyword must begin in column 1; it specifies that the cards which follow define the luminaires to be used and their locations.

HB57

This card specifies the name of the file which contains the photometric candela values for the luminaire we are using. For the present we will content ourselves with simply knowing the file name; we will not worry about whose account the file is in nor the values it contains. This latter information is discussed fully in Section V.

6300. .82

This card gives, respectively, the total initial lamp lumens and the light loss factor to be used. The initial lamp lumens value is the initial lumen rating for one lamp multiplied by the number of lamps in the luminaire. The light loss factor (a real number in the range 0 - 1) is a factor which accounts for lamp lumen depreciation, luminaire dirt accumulation, luminaire corrosion, ballast losses, etc.

1.833 3.833 0.5 92

This card specifies the following:

1.833 - the width of the luminous opening of the luminaire.

3.833 - the length of the luminous opening of the luminaire.

Note that the length and width of the luminaire are independent of the luminaire's orientation in the room. To determine these values, imagine the luminaire positioned so that its 0 degree photometric plane is pointed north. Then the width is the E-W span of the luminous opening and the length is the N-S span of the luminous opening. For fluorescent luminaires, this 0 degree photometric plane is almost always parallel to the lamps. For HID luminaires (mercury vapor, metal halide, high-pressure sodium) with a horizontal lamp, the zero degree photometric plane is generally parallel to the arc tube of the lamp.

0.5 - is the height of the luminaire. Unless a fixture has both uplight and downlight, this value may be specified as zero.

92 - says that the luminaire consumes 92 watts. This value only influences the calculations when an energy profile is being calculated, but it is recommended that the user cultivate the habit of always specifying it.

0 0 0 0

This card contains 4 values which are used in energy profile calculations. The meaning of the values for energy profiles is discussed later in the section. If energy profile computations are not being performed, four zeroes should be on the card.

6

This card tells the program that we are going to locate six luminaires within the room.

```
1  10 10 9.5  0 0 0
2  20 10 9.5  0 0 0
3  30 10 9.5  0 0 0
4  10 20 9.5  0 0 0
5  20 20 9.5  0 0 0
6  30 20 9.5  0 0 0
```

These six cards locate the luminaires within the room. The first number on each card gives the sequence number of the luminaire; this integer is present to enhance the readability of the input deck. The next 3 numbers (e.g., 10 10 9.5 on the first card) give the (x,y,z) coordinates of the center of the luminous opening of the luminaire. (The z-coordinate is 9.5 since the flush-mounted luminaires are 6" deep.) The last three numbers (here 3 zeroes on each card) give the angular orientation of the luminaire. The first of the 3 numbers is the "bearing", the second is the "tilt", and the third is the "cant" angle. These orientation angles are described in detail in Section IV. Here, let us be content to observe that the tilt will almost always be zero. The bearing angle specifies the direction in which the 0 degree photometric plane of the luminaire is oriented (0 = north, 90 = east, 180 = south, -90 = west). A luminaire which is not tilted or canted in any way has both tilt and cant angles = zero. Using a cant angle = 180 means that the luminaire is to be inverted from the position in which it was photometered.

CALCULATE

This keyword must begin in column 1. It signifies that the following card will specify the quantities to be computed.

ESI HOR VCP

These three keywords specify that ESI (Equivalent Sphere Illumination), Horizontal Fc (no body shadow), and VCP (Visual Comfort Probability) are to be computed. Each keyword is exactly three characters; the first keyword must begin in column 1 and each pair of keywords must be separated by exactly one space.

P25B
P25T

These are the filenames which identify the files containing BRDF factors used for computing, respectively, the background and task luminance at each target point. These latter values are used in turn to compute ESI. Refer to Section V for details on the contents of these files. If ESI is not being calculated, these cards may be omitted.

The following remarks apply in general to the input data deck:

1. Data values are one of three types -- real numeric, integer numeric, or alphabetic. The following rules govern their use:

a) Real values may be coded on the card with or without a decimal point. In this manual, where a numeric datum is not explicitly identified as real or integer, it is understood to be real.

b) Integer values must be coded on the card without a decimal point.

c) Numeric data values need not appear in any specific column on the card. It is only necessary to separate consecutive numeric values with a comma and/or one or more spaces.

d) Alphabetic data must always be coded beginning in the column specified.

2. The 3-dimensional (x,y,z) coordinate system used in describing the environment has its origin at the southwest corner of the floor. The +x direction is to the room east; the +y direction is to the room north, and the +z direction is straight up. Thus, any point within the room has all non-negative coordinates. This same coordinate system, as we shall see, is used for locating entities outside the room, such as other buildings.

3. In general, room north will not coincide with true north, and the algorithms require no certain relationship between these two "norths". However, it is recommended that the user designate his walls so that room north is as close as possible to true north.

3.2 Inverted Luminaires

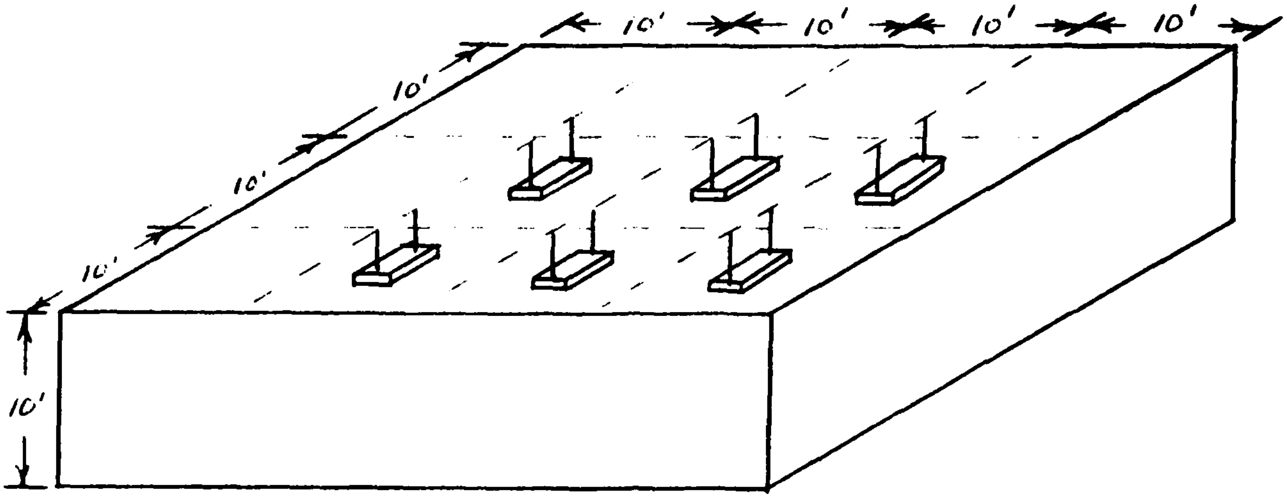

Figure 2: Room Layout for Example 2. Luminaires are suspended on 2' stems.

Let us leave the layout for example 1 essentially unchanged, except that we wish to suspend the luminaires on 2' stems, then invert them so they are "shining" at the ceiling. The input deck will look like this:

```
ROOM
EXAMPLE 2 -  40 X 30 X 10 ROOM WITH LUMINAIRES INVERTED
REFLECTANCES:  (WALLS = 50%, FLOOR = 20%, CEILING = 80%)
SIX 2-LAMP FLUORESCENT LUMINIARES (PHOTOMETRIC FILE 'HB57')
   3150 LUMENS PER LAMP  --  LUMINAIRES INVERTED 2' BELOW CEILING
NO FURNITURE OR DAYLIGHT.  CALCULATIONS:  ESI, HORIZ FC
  1  1
40 20  30 15  10 5
.5 .5 .5 .5 .2 .8
TASK
UNKNOWN
 20 15  1 39  1 29  2.5  4.0
  4
0. 90. 180. -90.
LUMINAIRES
HB57
6300.  .82
```

```
1.833 3.833 0.5   92
0 0 0 0
  6
1  10 10 8  0 0 180
2  20 10 8  0 0 180
3  30 10 8  0 0 180
4  10 20 8  0 0 180
5  20 20 8  0 0 180
6  30 20 8  0 0 180
CALCULATE
ESI HOR
P25B
P25T
```

Note the following changes in the data deck:

1. The cant angle is now 180 degrees in each case -- this inverts each luminaire.

2. We did not ask for VCP this time, as VCP is not defined for completely indirect lighting systems.

3. The z-coordinate of each luminaire is 8 (not 7.5); the z-coordinate is always the distance from the floor to the luminous opening of the fixture.

3.3 Rotated Luminaires

For this example we shall return to flush-mounted ceiling fixtures. The luminaire positioning remains the same as for example 1. However, we make the following two changes:

1) The "outside" columns of luminaires will be fixtures of a different type -- photometric file 'HB61', luminous opening 45" x 22" (3.75' x 1.833'), 2 fluorescent lamps each rated 3300 lumens.

2) The outside columns of luminaires are to be rotated so that the long dimension of each fixture runs east-west.

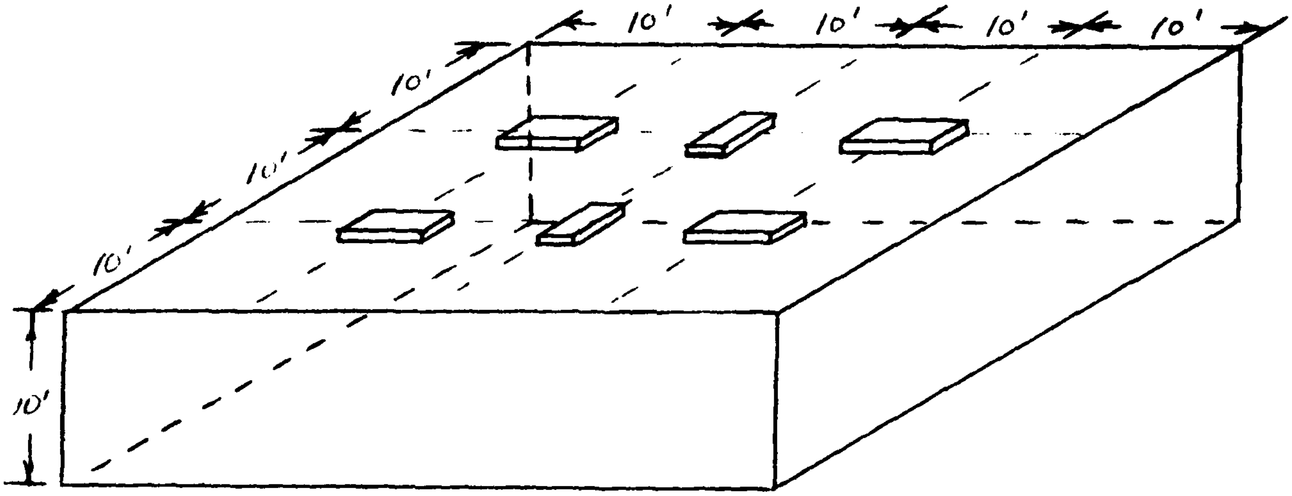

Figure 3: Layout for Example 3. Outside columns of luminaires are 'HB61'; center column of luminaires are 'HB57'.

The input data deck looks like this:

```
ROOM
EXAMPLE 3 -  40 X 30 X 10 ROOM  -- 2 LUMINAIRE TYPES,
   OUTSIDE COLUMNS ROTATED 90 DEGREES.
CENTER LUMINAIRES - PHOTOMETRIC 'HB57', 2 LAMPS, EACH 3150 LUMENS
OUTSIDE LUMINIARES - PHOTOMETRIC 'HB61', 2 LAMPS, EACH 3300 LUEMNS
NO FURNITURE OR DAYLIGHT.  CALCULATIONS:  ESI, HORIZ FC
  1  1
40 20  30 15  10 5
```

```
.5 .5 .5 .5 .2 .8
TASK
UNKNOWN
 20 15  1 39  1 29  2.5  4.0
  4
0. 90. 180. -90.
LUMINAIRES
HB57
6300.  .82
1.833 3.833 0.5  92
0 0 0 0
  2
1  20 10 9.5  0 0 0
2  20 20 9.5  0 0 0
LUMINAIRES
HB61
6600.  0.81
1.833 3.75 0.5  92
0 0 0 0
4
3  10 10 9.5  90 0 0
4  10 20 9.5  90 0 0
5  30 10 9.5  90 0 0
6  30 20 9.5  90 0 0
CALCULATE
ESI HOR
P25B
P25T
```

Note that the outside columns of luminaires were specified in a separate card block headed by its own LUMINAIRES keyword. Also note that the sequential numbering of luminaires does not start at 1 again in the second LUMINAIRES block. Note that the desired luminaire rotation is achieved by setting the bearing angle equal to 90 degrees.

3.4 Room Surface Inserts

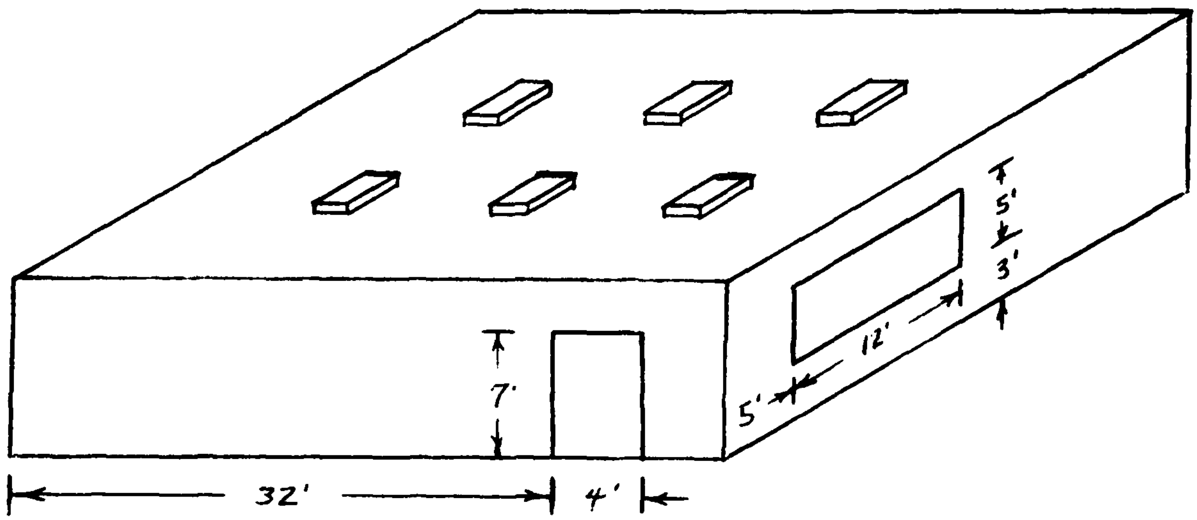

Figure 4: Room Layout for Example 4. This example illustrates room surface inserts -- in this case a door and chalkboard.

The luminaire arrangement shall be identical to that in Example 1. We shall specify two room surface "inserts" -- i.e., areas on walls, floor, or ceiling which have reflectance which is different from that of the underlying surface. These inserts are a 4' x 7' door with 35% reflectance, and a 5' x 12' chalkboard of reflectance 11%. These are located on the south and east walls, as shown in Figure 4. The input data deck is:

```
ROOM
EXAMPLE 4 -  ILLUSTRATING TWO INSERTS
REFLECTANCES - (WALLS= 50%, FLOOR = 20%, CEILING = 80%)
  SIX 2-LAMP FLUORESCENT LUMINAIRES
NO FURNITURE OR DAYLIGHT
CALCULATIONS:  ESI AND HORIZONTAL FC
  1 1
40 20  30 15  10 5
.5 .5 .5 .5 .2 .8
INSERTS
 2
4  0.35  32 36  0 0  0 7
```

```
3  .11  40 40  5 17  3 8
TASK
UNKNOWN
 20 15  1 39  1 29  2.5  4.0
  4
0. 90. 180. -90.
LUMINAIRES
HB57
6300.  .82
1.833 3.833 0.5  92
0 0 0 0
  6
1  10 10 9.5  0 0 0
2  20 10 9.5  0 0 0
3  30 10 9.5  0 0 0
4  10 20 9.5  0 0 0
5  20 20 9.5  0 0 0
6  30 20 9.5  0 0 0
CALCULATE
ESI HOR
P25B
P25T
```

The input cards we have not previously encountered mean the following:

INSERTS

This keyword must begin in column 1. It signals the program that insert definitions appear on the following cards.

 2

This card contains an integer value giving the number of inserts to be defined.

4 0.35 32 36 0 0 0 7

This card defines the door insert as follows:

4 - the door is on surface 4 (the south wall).

0.35 - the reflectance of the door.

32 36 - the lower and upper x-coordinates, respectively, of the door.

0 0 - the lower and upper y-coordinates of the door (both zero since the door lies on the south wall).

0 7 - the lower and upper z-coordinates of the door.

3 .11 40 40 5 17 3 8
This card defines the chalkboard insert as follows:

3 - the board is on surface 3 (the east wall).

.11 - the reflectance of the board.

40 40 - the lower and upper x-coordinates of the board (both 40 since the board lies on the east wall).

5 17 - the lower and upper y-coordinates of the board.

3 8 - the lower and upper z-coordinates of the board.

Note that insert locations are specified by 3 pairs of coordinate. One of the 3 pairs must always have 2 equal values, depending upon the surface on which the insert lies.

3.5 Obstructions within the Room

CEL-1 can take into account the presence of desks, cabinets, etc., within the room. We shall refer to any such object in the room as an obstruction. So as to minimize the size of the input data deck, the dimensions and reflectances of each obstruction are not included as part of the input deck. Rather, the dimensions and reflectances are stored in a permanent disc file (called the obstruction database). This means that the user can define the obstruction in the input data deck by simply giving its location and orientation in the room and by giving its sequential position within the database.

Section V describes in detail the structure and maintenance of the database. For the present discussion we shall take for granted the existence of the desired entries in the database. We are interested in these two obstructions:

1. A desk 6' across x 3' deep x 2.5' high. Reflectances are 15% on all 4 sides and 30% on top.

2. A partition 6' high x 12' across x 5" thick. The 2 large partition surfaces have reflectance = 45%. The small thin surfaces each have reflectance 20%.

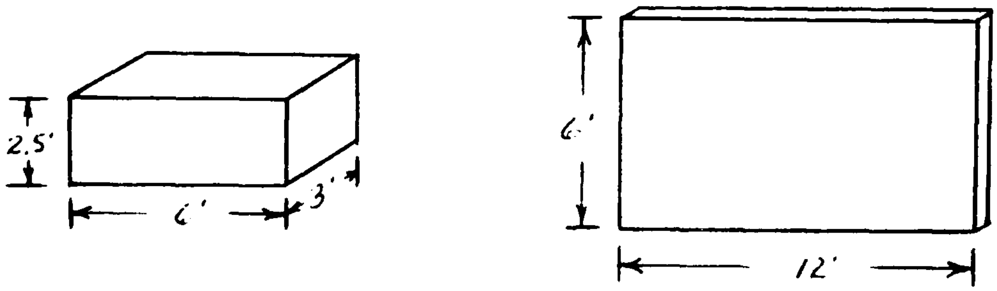

Figure 5a: The obstructions used in Example 5. The partition on the right is 5 inches thick.

In the database, an obstruction is specified as a 3-dimensional rectangular object: 3 dimensions (N-S, E-W, and height) and 5 reflectance values exist in the database. Let us assume that in the database definition the desk is the third sequential entry and that its 6' dimension runs east-west. We assume that the partition is the eighth sequential entry in the database and that its 12' dimension runs east-west.

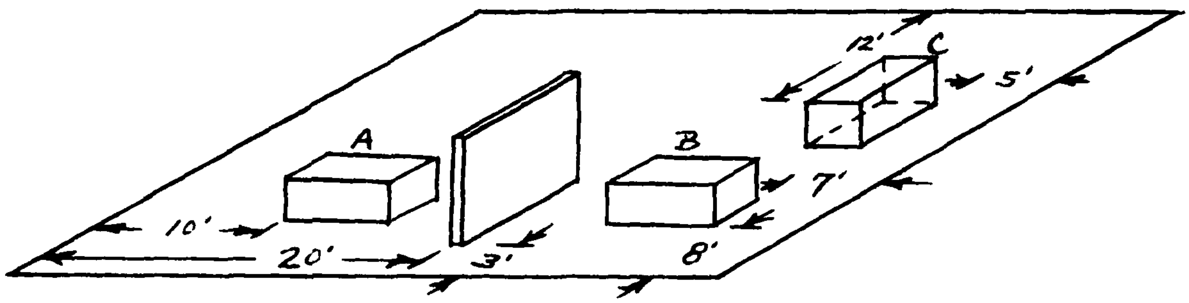

Figure 5b: The Layout for Example 5. Walls and ceiling are not shown.

We shall position the desks and partition as shown in Figure 5b. The workers at desks A and B will be seated facing north; the worker at desk C will be seated facing west. Since we now know where the office tasks are to be performed, we are no longer interested in the 2' x 2' grid of target points we have used heretofore. Instead, we shall call for calculations at the known task locations (the desks). The input deck looks like this:

```
ROOM
EXAMPLE 5 - ILLUSTRATING OBSTRUCTIONS AND KNOWN TASK LOCATIONS.
SIX 2-LAMP FLUORESCENT LUMINAIRES
TWO ROOM INSERTS
NO DAYLIGHT
CALCULATIONS: HORIZONTAL FC, ESI (ESI RATINGS)
 1  1
40 20   30 15   10 5
.5 .5 .5 .5 .2 .8
INSERTS
 2
4  0.35   32 36   0 0   0 7
3  .11   40 40   5 17   3 8
TASK
RATING
 3  2.5  1
13 8.5  0
30 8.5  0
34.5 15  -90
FURNITURE
 4
3  13 9.5 2.5  0
3  30 9.5 2.5  0
3  33.5 15 2.5  -90
8  20 9 6  90
```

```
LUMINAIRES
HB57
6300.  0.82
1.833 3.833 0.5  92
0 0 0 0
  6
1  10 10 9.5  0 0 0
2  20 10 9.5  0 0 0
3  30 10 9.5  0 0 0
4  10 20 9.5  0 0 0
5  20 20 9.5  0 0 0
6  30 20 9.5  0 0 0
CALCULATE
ESI HOR
P25B
P25T
```

The previously undiscussed cards in this deck are:

RATING

This keyword must begin in column 1. The cards which follow define points for which ESI Ratings are to be calculated. An "ESI Rating" is defined in detail in Section IV. Briefly, it is determined by computing ESI at 8 different points within a 2' x 1' rectangle and then taking a logarithmic average of the values computed.

3 2.5 1

This card specifies that 3 task locations are to be subsequently defined, each 2.5 feet above the floor. The third number on the card is an integer value which selects the IES option (=1) or the Navy option (=2) for the ESI rating calculation. For details on these options, refer to Section IV.

13 8.5 0

This card defines a task location at (x,y) = (13,8.5). The 0 value is the observer's primary viewing direction -- in this case, north. This is the calculation point for desk A.

30 8.5 0

defines the task location for desk B -- (x,y) = (30,8.5). The observer viewing direction is 0 degrees (north).

34.5 15 -90

defines the task location for desk C -- (x,y) = (34.5,15). The observer viewing direction is -90 degrees (west).

FURNITURE

This keyword must begin in column 1. It signals the program that the cards which follow locate obstructions within the room.

4

This card contains one integer value telling how many obstruction locations are to be defined.

3 13 9.5 2.5 0

The values on this card locate desk A. The numbers mean the following:

3 - the desk is the 3rd entry in the database file where all obstructions are defined.

13 9.5 2.5 - these are the (x,y,z) coordinates of the top center of the desk.

0 - the rotation angle of the desk, relative to its databasse definition. In this case, the orientation is to be the same as in the database definition.

3 30 9.5 2.5 0

This card locates desk B in the room. The numbers have similar interpretation to those for the previous card.

3 33.5 15 2.5 -90

This card locates desk C in the room. Note that desk C has been rotated 90 degrees counter-clockwise, relative to its database orientation. (Since the reflectance is the same on each side, a clockwise 90 degree rotation would have accomplished the same result.)

8 20 9 6 90

This card locates the partition within the room:

8 - the partition is the 8th entry in the database file.

20 9 6 - the (x,y,z) coordinates of the top center of the partition.

90 - the partition has been rotated 90 degrees clockwise, relative to its orientation in the database.

Note the following:

1. An object is located in the room by specifying the (x,y,z) coordinate of the center of its top surface.

2. Task locations are specified independently of any desk locations. It is not necessary to locate a desk at any task location, nor is it necessary to locate a task at each desk. In particular, ESI Ratings may be calculated even though no obstructions are defined in the room.

3.6 Daylight Calculations

Several considerations arise when using CEL-1 for daylight calculations. Among them are:

1. The sky brightness depends upon the location of the sun. Hence daylight computations for a given instant require knowledge of the room's location on earth (latitude, longitude), along with the day-of-the-year and time-of-day.

2. The room's orientation relative to true north must be known.

3. The locations and reflectances of any nearby buildings (provided they are visible thru the room's fenestration) must be known.

4. The reflectance of the ground must be known.

Two modes of daylight calculation are available:

3.6.1 Analysis Mode

In this mode, the user specifies the room layout and luminaire locations (if any) and target point locations, just as in the previously-discussed examples. He also specifies the fenestration through which daylight may enter the room. Finally, one or more time instants during the year are specified. For these static sets of conditions, results are calculated at the target points just as in the previous examples where no daylight was to be considered.

Knowing the effects of daylight at one, or even several, given instants throughout the year is of questionable value. However, analysis mode may be used in conjunction with profile mode to arrive at a dimming strategy for luminaires or to determine where luminaire-controlling light sensors are to be placed. These suggestions are expanded upon in the discussion to follow.

3.6.2 Profile Mode

In this mode the user does not specify any particular instants during the year. Rather, he specifies a dimming strategy for the luminaires present. The program then computes, for a typical day in each month, the energy consumed (hour-by-hour) when the luminaires are dimmed according to the amount of daylight present. This enables the user to compare 2 or more luminaire systems, 2 or more dimming strategies, etc. This mode would also seem to be a powerful research tool which could be used to evaluate the economic feasibliity of luminaire dimming systems.

3.6.3 Windows

Let us take the room layout and task locations from example 5, but we shall eliminate the inserts. We wish to account for 3 windows as shown in Figure 6a. Each window is 5' high and 8' across; the tinted glass on the windows has 80% transmissivity.

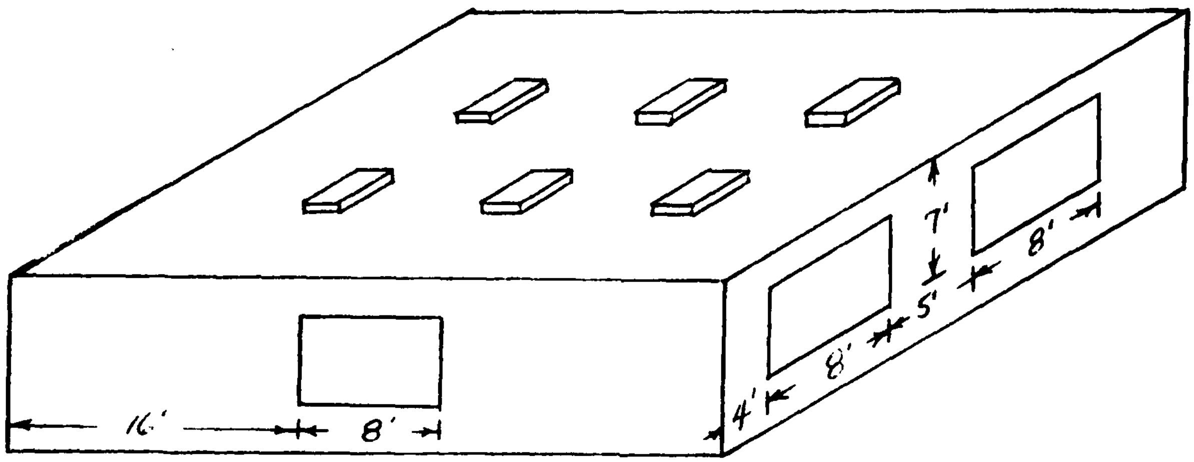

Figure 6a: Window and luminaire locations for Example 6.

In addition, we must specify the external environment; refer to Figure 6b. First, we must consider the building in which our room lies (this we will call the "object building"). The object building is 250' x 250' and is 45' high. The west wall of the room is 100' east of the west wall of the object building. The floor of the room is 35' above ground level (since the room has a 10' ceiling, this implies that the room ceiling coincides with the roof of the object building). The object building west wall is such that the wall runs in a direction which is rotated 30 degrees counter-clockwise (-30 degrees) from true north. Thus we may say that the object building orientation relative to true north is -30 degrees. Note that this must also be the room orientation relative to true north.

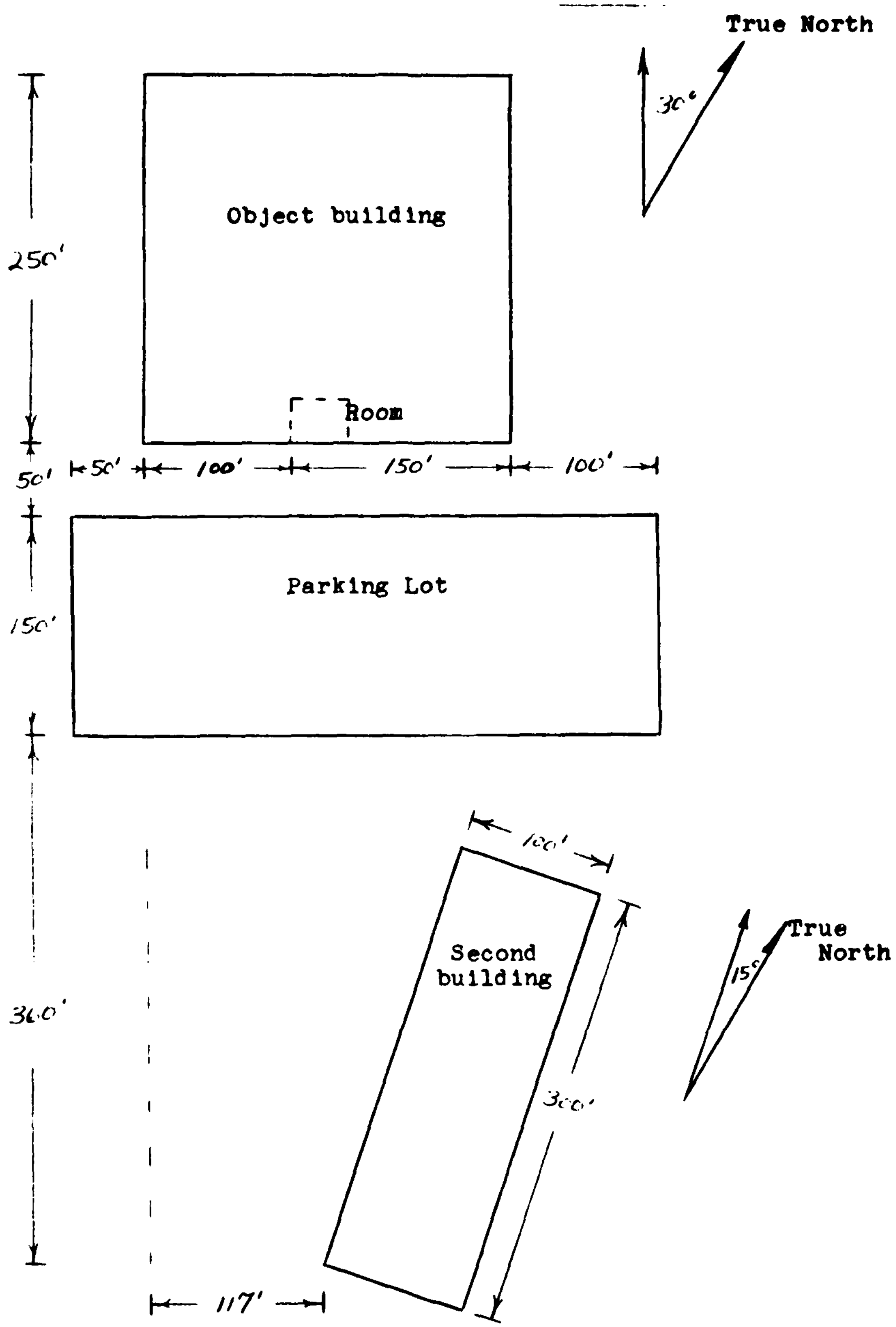

Figure 6b: External environment for daylight calculations for Example 6.

A parking lot lies immediately opposite the object building south wall; the lot is 150' x 400' and has reflectance = 8%. A second building (300' long by 100' wide) lies as shown in Figure 6b; this building is 80' high and lies 15 degrees counter-clockwise of true north. Here is the data deck:

```
ROOM
EXAMPLE 6 -  ILLUSTRATING THE USE OF WINDOWS
3 WINDOWS. EACH 5' X 8', 80% TRANSMITTING
  NO INSERTS
LONGITUDE = 83.1  LATITUDE = 42.4
SAME LUMINAIRE LAYOUT AS FOR EXAMPLE 1
 1 1
40 20  30 15  10 5
.5 .5 .5 .5 .2 .8
TASK
RATING
 3 2.5 1
13 8.5  0
30 8.5  0
34.5 15  -90
FENESTRATION
WINDOW
 1 0.80
8 5
 3
4  16 0 3
3  40 4 3
3  40 17 3
BUILDING
  2
-100 0 -45  250 250 45
.6 .6 .6 .6 .2
-30
17 -560 -35  100 300 80
.5 .5 .5 .5 .5
-15
GROUND
 .12
  1
.08  -150 250  -200 -50  -35
FURNITURE
  4
3  13 9.5 2.5  0
3  30 9.5 2.5  0
3  33.5 15 2.5  -90
8  20 9 6  90
ANALYSIS
 42.4 83.1  75.  2
0 0 0 0 1 1 1 1 1 1 0 0
 2
4 22 16.50
7 4 8.25
```

```
LUMINAIRES
HB57
6300.  .85
1.833 3.833 0.5  92
0 0 0 0
  6
1  10 10 9.5  0 0 0
2  20 10 9.5  0 0 0
3  30 10 9.5  0 0 0
4  10 20 9.5  0 0 0
5  20 20 9.5  0 0 0
6  30 20 9.5  0 0 0
CALCULATE
ESI HOR
P25B
P25T
```

The cards we have not yet encountered have the following meanings:

FENESTRATION

This keyword begins in column 1. It signals the program that a description of the daylighting environment is to follow.

WINDOW

This keyword, which begins in column 1, is followed by the definition of a window.

 1 0.80

The first value is an integer which describes the nature of the glazing (glazing is usually glass) on the window. The 1 value means the glazing is clear (image-preserving). A 2 value would mean diffuse (opaque) glazing. The second value on the card gives the transmittance of the glazing.

8 5

The two real values on this card give. respectively, the width and height of the window opening.

 3

The integer value on this card tells how many windows of this type are on the room walls.

```
4  16 0 3
3  40 4 3
3  40 17 3
```

These cards locate the three windows on the walls. The first value on each card is an integer which gives the room surface number on which the window lies. The next 3 values are real numbers which are the (x,y,z) coordinates of that corner of the window opening which is nearest to the room origin. For example, the card

3 40 4 3

locates a window on the east wall. The lower south corner of the window is at (x,y.z) = (40,4,3).

BUILDING

This keyword begins in column 1 and indicates that subsequent cards describe the buildings which are present.

2

The integer value on this card tells how many buildings are described on the cards to follow.

-100 0 35 250 250 45

This card gives the dimensions and locations of the first building (the "object" building) as follows:

-100 0 -35 these three real numbers are the (x,y,z) coordinate locations of the southwest corner of the building at ground level. Note that these coordinates (and any coordinates in the data deck) are relative to the room origin.

250 250 45 these three real numbers give the width, length, and height, respectively, of the building.

.6 .6 .6 .6 .2

These 5 real numbers give. in order, the reflectances of the five exposed building surfaces -- west wall, north wall, east wall, south wall, roof. In this case all the building walls have 60% reflectance, while the roof has 20% reflectance.

-30

The real number on this card gives the angular displacement of the building from true north. -30 in this case says that the building has been rotated 30 degrees counterclockwise from true north.

17 -560 -35 100 300 80
.5 .5 .5 .5 .5
-15

These three cards describe the second building. Note that the reflectances of the building are everywhere 50%.

GROUND

This keyword begins in column 1; it is followed by the ground reflectance and any ground "insert" definitions.

.12
This card gives the ground reflectance.

1
This card has one integer value giving the number of ground inserts to be defined.

.08 -150 250 -200 -50 -35
This card defines the parking lot as follows:

.08 - the reflectance of the lot.

-150 250 - the x-coordinates of the leftmost and rightmost, respectively, boundaries of the parking lot.

-200 -50 - the y-coordinates of the lower and upper boundaries of the parking lot.

-35 - the z-coordianate of the parking lot.

ANALYSIS
This keyword begins in column 1; it invokes the daylight "analysis" mode for CEL-1 calculations.

42.4 83.1 75. 2
This card describes the external environment as follows:

42.4 - the latitude of the room. A positive value locates a room in the northern hemisphere; a negative latitude is in the southern hemisphere.

83.1 - the longitude of the room. A positive value locates a room in the western hemisphere; a negative longitude is in the eastern hemisphere.

75. - the longitude at the center of the time zone in which the room lies. In this example, 75. is the longitude at the center of the Eastern Time Zone.

2 - this is an integer which identifies the weather station from which the cloudiness data is to be obtained. The value represents the station's sequential position in the "cloudiness" database (in this case, therefore, the desired station is the second in the database). See Section V for a detailed discussion of the "cloudiness" database.

0 0 0 0 1 1 1 1 1 1 0 0

This card is the "Daylight Savings Time" map. Each of the twelve integer values corresponds in chronological order to one of the twelve months of the year. A zero value means daylight savings time is not in effect during the corresponding month; a 1 value means that daylight savings time is in effect during the month. In this example, daylight savings time is to be in effect from May thru October and not in effect the other six months

2

The integer value on this card tells CEL-1 how many instants of time during the year daylight calculations are to be performed for. The maximum number of instants allowed is 15.

4 22 16.50
7 4 8.25

These cards specify the instants of time for which calculations are to be performed. The first two values on each card are integers which give, respectively, the month and day. The third value (real) gives the time of day in decimal form based on a 24-hour clock. These two cards request calculations for 4:30 pm on April 22, and for 8:15 am on July 4.

Note the following:

1. The BUILDING sub-block of cards is always required, since the object building must always be described (the object building is the building which contains the room under analysis).

2. A GROUND sub-block of cards is always required, since the reflectance of the ground must always be given.

3. The (x,y,z) coordinates of buildings are given relative to the room origin. The 3 coordinate axes are the same as those used for locating points within the room. The first building described is always the object building; its orientation relative to true north is also the room orientation relative to true north.

3.7 Drapes

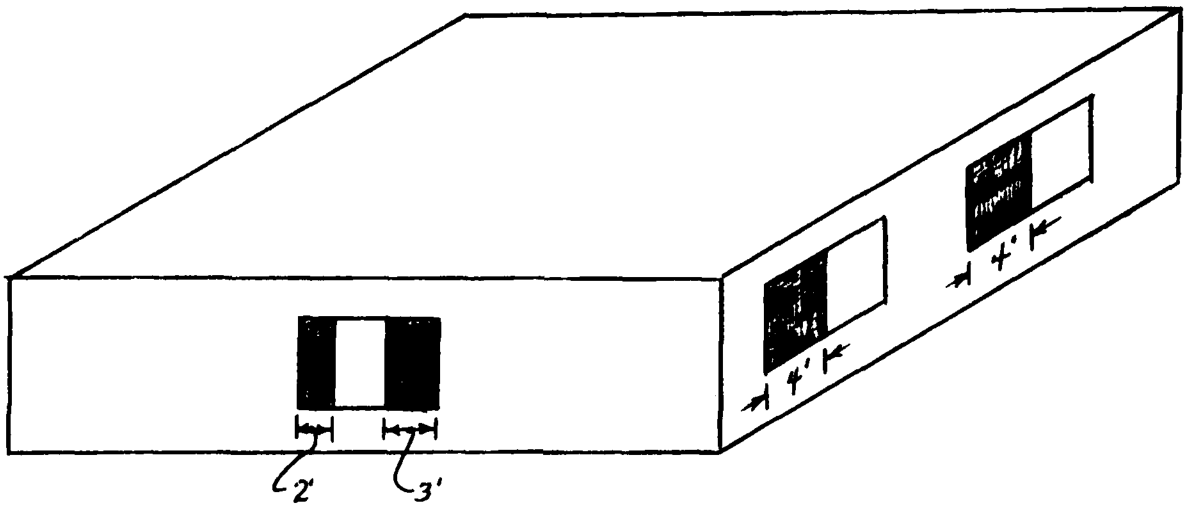

Figure 7 : Same layout as Example 6, except windows partially covered by drapes (shaded areas).

Drapes are assumed by CEL-1 to be diffuse coverings over a portion of a window opening. The drapes are assumed to cover the entire vertical span of the window opening; they are "closed" from either or both edges. Figure 7 depicts the drapes on each window as shaded areas. The input data deck looks like this:

```
ROOM
EXAMPLE 7 -  ILLUSTRATING WINDOWS WITH DRAPES
DRAPES CLOSED FROM EACH SIDE ON SOUTH WINDOW.
DRAPES CLOSED FROM LEFT SIDE ONLY ON EAST WINDOWS.
EXCEPT FOR PRESENCE OF DRAPES, ALL OTHER ASPECTS OF LAYOUT ARE
   IDENTICAL TO THAT FOR EXAMPLE 6.
 1 1
40 20  30 15  10 5
.5 .5 .5 .5 .2 .8
TASK
RATING
 3 2.5 1
13 8.5  0
30 8.5  0
34.5 15  -90
FENESTRATION
WINDOW
 1 0.80
8 5
 1
4  16 0 3
```

```
DRAPE
 0.25  3  2
WINDOW
 1 0.80
8 5
 2
3  40 4 3
3  40 17 3
DRAPE
0.25 0 4
BUILDING
 2
-100 0 -45  250 250 45
.6 .6 .6 .6 .2
-30
17 -560 -35  100 300 80
.5 .5 .5 .5 .5
-15
GROUND
 .12
  1
.08  -150 250  -200 -50  -35
FURNITURE
 4
3  13 9.5 2.5  0
3  30 9.5 2.5  0
3  33.5 15 2.5  -90
8  20 9 6  90
ANALYSIS
 42.4 83.1  75.  2
0 0 0 0 1 1 1 1 1 1 0 0
 2
4 22 16.50
7 4 8.25
LUMINAIRES
HB57
6300.  .85
1.833 3.833 0.5  92
0 0 0 0
  6
1  10 10 9.5  0 0 0
2  20 10 9.5  0 0 0
3  30 10 9.5  0 0 0
4  10 20 9.5  0 0 0
5  20 20 9.5  0 0 0
6  30 20 9.5  0 0 0
CALCULATE
ESI HOR
P25B
P25T
```

The cards in the DRAPE sub-block are as follows:

DRAPE

This keyword must begin in column 1.

0.25 3 2

This card says that the drape material has 25% transmittance and that the closure distance is 3' from the left edge of the window and 2' from the right edge.

DRAPE
0.25 0 4

These 2 cards describe the drapes on the east windows. Note the following:

1. Although all three windows have the same dimensions, glazing, and transmittance, two separate WINDOW sub-blocks are necessary since the drapes on the south wall have different closure from those on the east wall.

2. When determining the closure distance of drapes, the "left" and "right" window edges are determined by viewing the window from inside the room.

3.8 Blinds

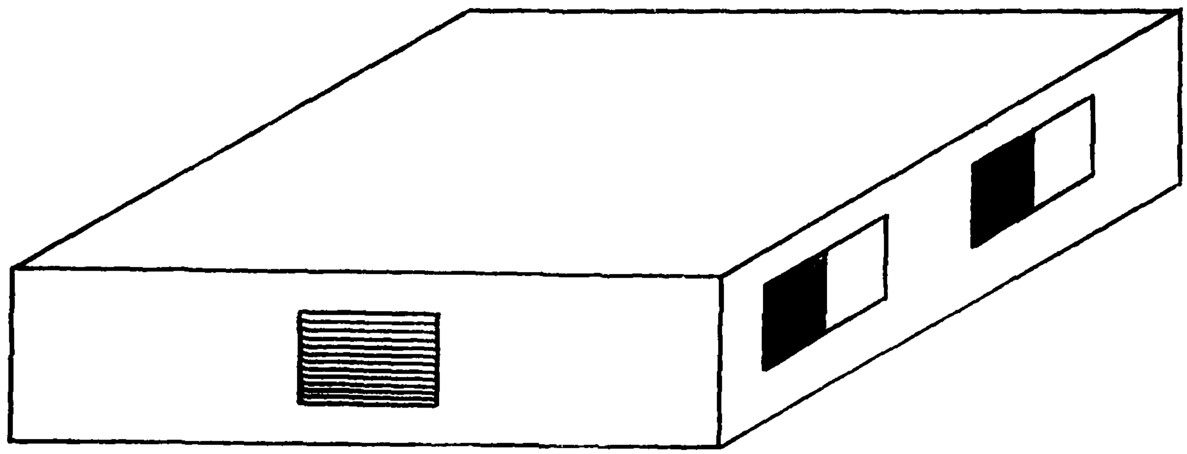

Figure 8a: Example 8 Window configuration. Layout is identical to that for Example 7, except that drapes on south wall have been replaced by horizontal blinds.

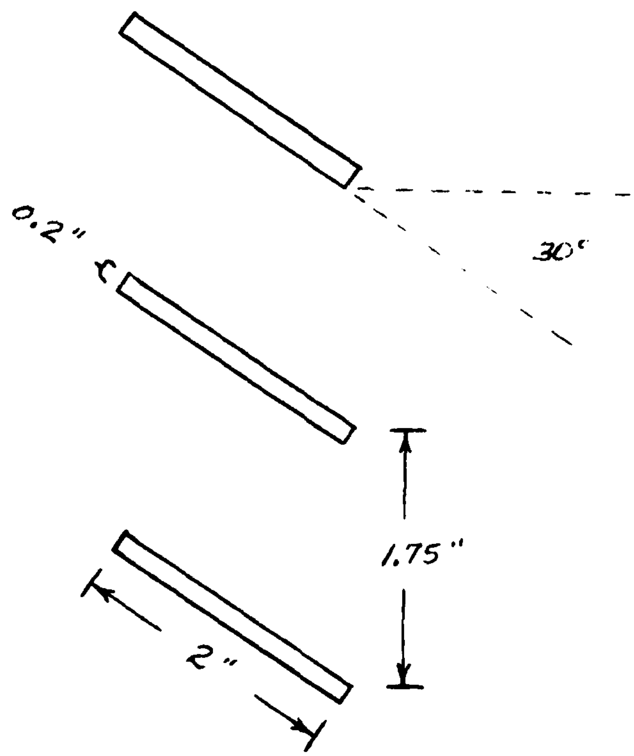

Figure 8b: Detailed close-up of blinds used in Example 8. This is a cross-section view.

CEL-1 handles either horizontal or vertical blinds on windows. The blinds may be closed to any desired angle. Example 8 is very similar to example 7, except that we shall replace the drapes on the south window with horizontal venetian blinds. The thickness of each blind is 0.2 inch (= .0167 feet); the width of each blind is 2 inches (0.167 feet); the spacing between blinds is 1.75 inches (0.146 feet). Reflectance of the blinds is 70%. Here is the data deck:

```
ROOM
EXAMPLE 8 - ILLUSTRATING WINDOW WITH VENETIAN BLINDS
 -- THIS EXAMPLE IDENTICAL IN ALL RESPECTS TO EXAMPLE 7,
     EXCEPT THAT THE WINDOW ON THE SOUTH WALL HAS HORIZONTAL
     BLINDS INSTEAD OF DRAPES.

 1 1
40 20  30 15  10 5
.5 .5 .5 .5 .2 .8
TASK
RATING
 3 2.5 1
13 8.5  0
30 8.5  0
34.5 15  -90
FENESTRATION
WINDOW
 1 0.80
8 5
 1
4  16 0 3
BLINDS
 1  0.0167 0.167 0.146  30  .70
WINDOW
 1 0.80
8 5
 2
3  40 4 3
3  40 17 3
DRAPE
0.25 0 4
BUILDING
 2
-100 0 -45  250 250 45
.6 .6 .6 .6 .2
-30
17 -560 -35  100 300 80
.5 .5 .5 .5 .5
-15
GROUND
 .12
  1
.08  -150 250  -200 -50  -35
FURNITURE
 4
```

```
3  13 9.5 2.5  0
3  30 9.5 2.5  0
3  33.5 15 2.5  -90
8  20 9 6  90
ANALYSIS
 42.4 83.1  75.  2
0 0 0 0 1 1 1 1 1 1 0 0
 2
4 22 16.50
7 4 8.25
LUMINAIRES
HB57
6300.  .85
1.833 3.833 0.5  92
0 0 0 0
  6
1  10 10 9.5  0 0 0
2  20 10 9.5  0 0 0
3  30 10 9.5  0 0 0
4  10 20 9.5  0 0 0
5  20 20 9.5  0 0 0
6  30 20 9.5  0 0 0
CALCULATE
ESI HOR
P25B
P25T
```

The two cards defining the blinds are as follows:

BLINDS

The BLINDS keyword must begin in column 1.

 1 0.0167 0.167 0.146 30 .70

This card describes the blinds in detail:

1 - this integer value defines horizontal blinds; a 2 value would define vertical blinds.

0.0167 - the thickness of one blind

0.167 - the width of each blind.

0.146 - the spacing between blinds.

30 - the closure angle of the blinds (in degrees).

.70 - the reflectance of the blinds.

3.9 Skylights

CEL-1 permits skylight, clerestory, and sawtooth structures to be placed on the ceiling of the room. Here we illustrate an example of the use of a skylight structure and follow with some brief remarks on clerestory and sawtooth structures.

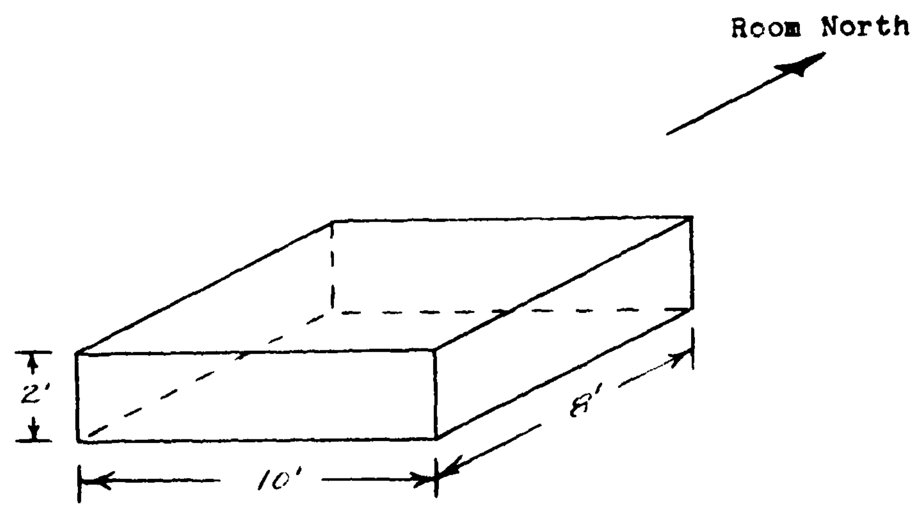

Figure 9a: Close-up detail of the skylight structure used in Example 9. North and south faces are non-transmitting; remaining three faces transmit daylight.

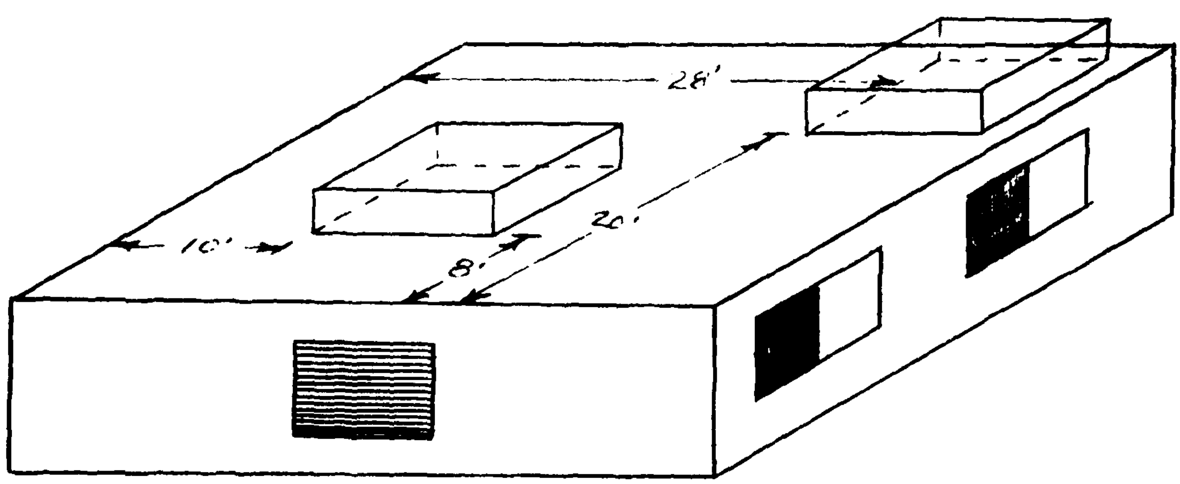

Figure 9b: Fenestration positions for Example 9. Layout is identical to that for Example 8, except for (1) addition of skylight structures and (2) deletion of luminaires.

A skylight structure can simply be a rectangular opening in the ceiling or it may be the protrusion of a 3-dimensional structure through a rectangular opening in the ceiling. In the latter case, the "roof" of the 3-dimensional structure must transmit daylight. Consider the skylight structure shown in Figure 9a. The top of the structure and the east and west faces each have transmissivity = 75%; the north and south faces are non-transmitting, each having reflectance = 83%. In addition to adding two such structures at the locations shown in Figure 9b, we shall drop the luminaires from the room. Here is the input data deck:

```
ROOM
EXAMPLE 9 -- ILLUSTRATING THE USE OF SKYLIGHTS
  -- THIS EXAMPLE SAME AS EXAMPLE 8 WITH THE FOLLOWING EXCEPTIONS:
  1) NO LUMINAIRES
  2) TWO SKYLIGHTS PRESENT ON CEILING.

 1 1
40 20  30 15  10 5
.5 .5 .5 .5 .2 .8
TASK
RATING
 3 2.5 1
13 8.5  0
30 8.5  0
34.5 15  -90
FENESTRATION
WINDOW
 1 0.80
8 5
 1
4  16 0 3
BLINDS
 1  0.0167 0.167 0.146  30  .70
WINDOW
 1 0.80
8 5
 2
3  40 4 3
3  40 17 3
DRAPE
 0.25  0 4.
SKYLIGHT
10. 8. 2. 1
.75 -.83 .75 -.83 .75
 2
10 8 10
28 20 10
BUILDING
 2
-100 0 -45  250 250 45
.6 .6 .6 .6 .2
-30
17 -560 -35  100 300 80
```

```
.5 .5 .5 .5 .5
-15
GROUND
 .12
  1
.08  -150 250  -200 -50   -35
FURNITURE
 4
3   13 9.5 2.5   0
3   30 9.5 2.5   0
3   33.5 15 2.5   -90
8   20 9 6   90
ANALYSIS
42.4 83.1  75.  2
0 0 0 0 1 1 1 1 1 1 0 0
 2
4 22 16.50
7 4 8.25
CALCULATE
ESI HOR
P25B
P25T
```

The cards in the *SKYLIGHT* sub-block have the following meanings:

SKYLIGHT
: This keyword must begin in column 1.

10. 8. 2. 1
: The first three values on this card are real numbers giving the width (E-W), length (N-S), and height of the structure. The fourth value is an integer which describes the glazing (1=clear, 2=diffusing).

.75 -.83 .75 -.83 .75
: This card gives, in order, the transmittances of the west, north, east, south, and top faces of the structure. A negative value means that the corresponding surface is non-transmitting; the absolute value of the negative number is the reflectance of the interior of the surface.

 2
: The integer value on this card tells how many of the above-defined skylight structures are to be located on the ceiling.

10 8 10
28 20 10
: Each of these two cards gives the (x,y,z) coordinates of the lower southwest corner of a skylight structure -- i.e., the corner of the structure which is nearest to the origin.

The following comments apply:

1. A skylight which is simply an opening in the ceiling is specified by assigning a height = zero and transmittances = zero on all four vertical surfaces.

2. The top surface must always transmit daylight; it is optional whether any of the remaining four surfaces will transmit daylight.

3. A clerestory structure is specified in a manner almost identical to that for skylights. The only difference is that the top surface of a clerestory structure must be non-transmitting. For complete details, refer to Section IV.

4. A sawtooth structure is specified by giving length, width, and height; the data deck also specifies the transmittance of the glazing, plus the reflectances of the vertical surfaces and of the sloping surface. Refer to Section IV for complete details.

3.10 The Energy Profile Feature

Suppose we have a room environment where our luminaires are controlled automatically in some fashion, so that their light output varies with the amount of daylight present. The control might be any one of the following types:

a) on-off — Each controlled luminaire operates at either zero or full output.

b) high-low-off — Each controlled luminaire operates at either zero, half, or full output.

c) continuous — Each controlled luminaire's output is continuously adjustable from full down to some specified threshold level.

If we link our luminaire dimming strategy to the lighting task at hand, it will then be possible to calculate how much energy the controlled luminaires consume under various daylighting conditions. This is precisely what the energy profile algorithm does -- its output is a collection of hour-by-hour profiles of the energy consumed by the luminaires. For each month, a typical day is chosen; three hour-by-hour profiles for the day are computed, one each for the sky conditions 1) clear, 2) partly cloudy, and 3) overcast. In addition, an expected energy consumption for the month is calculated -- this is based on the number of days of cloud conditions of each type which are anticipated during the month. Before proceeding to the examples, let us introduce two new concepts related to daylighting calculations -- "sensors" and "control target areas".

For CEL-1 a sensor is a location at which illuminance is to be computed. A sensor, unlike a target point, may be located on the room ceiling or even outside the room. In the real world, the illuminance at such sensors might be used to control one or more luminaires, and this is the reason they are allowed in CEL-1. However, locations defined as sensors in CEL-1 are not used to control luminaires. Luminaires are controlled by the values at target points or over a control target area. The virtue of being able to compute illuminance at sensor locations in CEL-1 is that the user can use this feature to determine good locations for real-world controlling sensors and to determine good threshold values to associate with these sensors.

A control target area is a rectangular grid defined on a horizontal plane (usually the task plane, though this not a requirement). Horizontal illuminance is computed at each point in the control target area; the illuminance values computed are used to control the luminaires.

3.10.1 Example 10 - Energy Profile

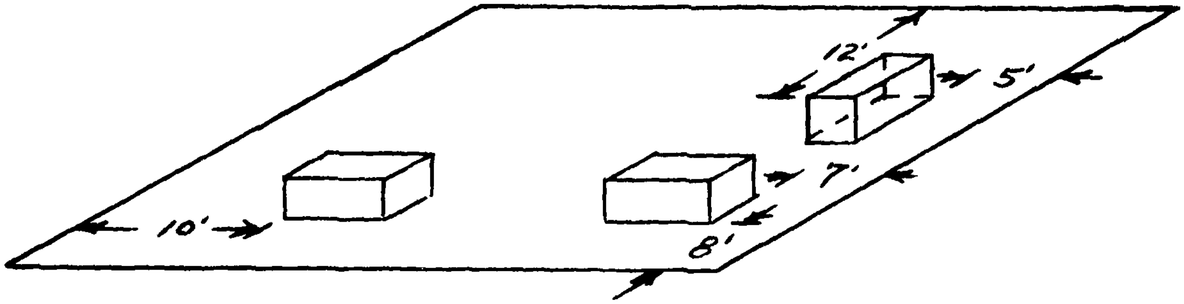

Figure 10a: Interior layout for Examples 10 and 11. This is the same as the interior layout for Example 6, minus one partition.

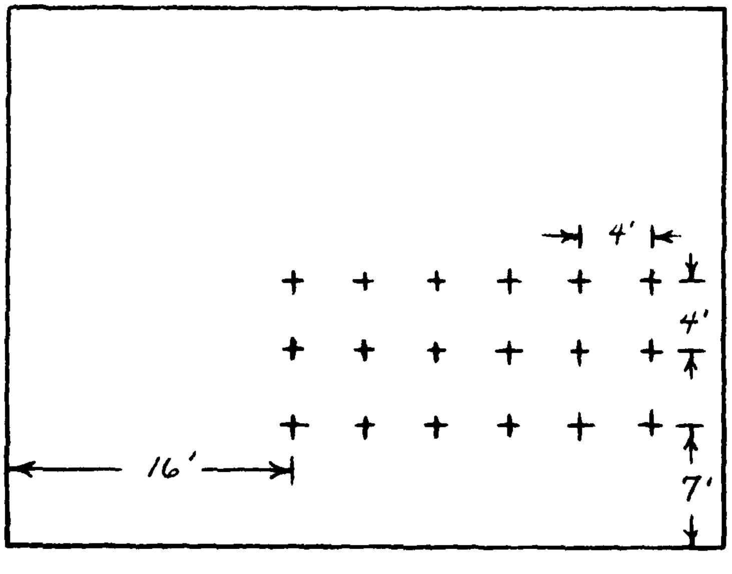

Figure 10b: + signs constitute the control target area for Example 10. This is a plan view.

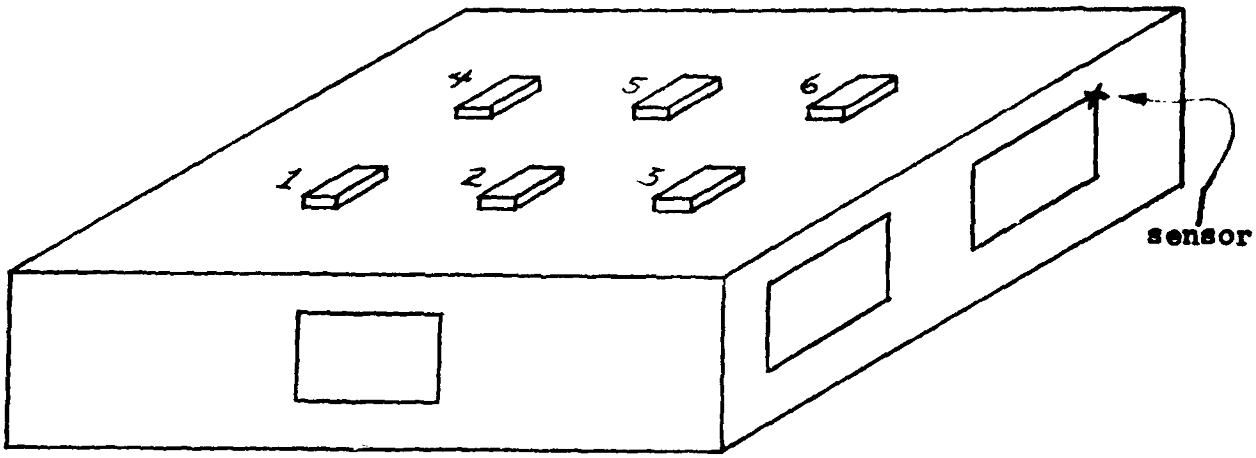

Figure 10c: Walls and ceiling for Examples 10 and 11. Dimensions and locations of windows and luminaires are the same as for Example 6.

Let us choose the same environment as for example 6, except we shall eliminate the partition. We shall define a rectangular control target area 2.5 feet above the floor as shown in Figure 10b. We shall control the luminaires as follows (see Figure 10c):

Luminaires 1, 4, 5 are to be always on.
Luminaires 2, 3. 6 are to be controlled according to the minimum illuminance on the control target area.

In addition, we place two sensors in the environment. The first sensor will be positioned at the exact center of the ceiling. The second sensor will be on the building wall, at the upper northernmost corner of the more northerly of the two windows on the east wall; the sensor will face toward room north. Here is the data deck:

ROOM

```
EXAMPLE 10 -- ILLUSTRATING AN ENERGY PROFILE CALCULATION
SAME LAYOUT AS EXAMPLE 6, EXCEPT NO PARTITION
LUMINAIRES 1. 4. AND 5 ALWAYS ON; LUMINAIRES 2, 3, 6 CONTROLLED
  ACCORDING TO MINIMUM ILLUMINANCE ON CONTROL TARGET AREA
 THRESHOLD ILLUMINANCE VALUES = 30 FC, 60 FC
 1 1
40 20  30 15  10 5
.5 .5 .5 .5 .2 .8
TASK
KNOWN
 3 2.5
13 8.5 0
30 8.5 0
34.5 15  -90
SENSORS
 1
20 15 10  5
 1
40 25 8  2
FENESTRATION
WINDOW
 1 0.80
8 5
 3
4  16 0 3
3  40 4 3
3  40 17 3
BUILDING
  2
-100 0 -35  250 250 45
.6 .6 .6 .6 .2
-30
17 -560 -35  100 300 80
.5 .5 .5 .5 .5
-15
GROUND
 .12
  1
.08  -150 250  -200 -50  -35
FURNITURE
  3
3  13 9.5 2.5  0
3  30 9.5 2.5  0
3  33.5 15 2.5  -90
PROFILE
 42.4 83.1  75.  2
0 0 0 0 1 1 1 1 1 1 0 0
0 0 0 0 0 0 0 0 1 1 1 1 0.5 1 1 1 1 0 0 0 0 0 0
LUMINAIRES
HB57
6300.  .85
1.833 3.833 0.5  92
0 0 0 0
  6
```

```
1  10 10 9.5  0 0 0
2  20 10 9.5  0 0 0
3  30 10 9.5  0 0 0
4  10 20 9.5  0 0 0
5  20 20 9.5  0 0 0
6  30 20 9.5  0 0 0
DIMMING
 1
30. 60.
0 0 1 0 0
6 3  16 36  7 15  2.5
 0
 3
2 3 6
CALCULATE
ESI HOR
P25B
P25T
```

The cards we have not previously encountered previously are explained as follows:

KNOWN

This keyword must begin in column 1. The cards which follow are almost identical to those used to define locations for ESI Rating calculations. KNOWN instructs CEL-1 that task locations will be defined individually (rather than as part of a rectangular grid), but that ESI Ratings are not to be computed. In such cases, ESI is evaluated only at the one point specified and for the one viewing direction.

 3 2.5

This card says that 3 task locations will be defined, each 2.5 feet above the floor.

13 8.5 0
30 8.5 0
34.5 15 -90

These 3 cards define the locations of each task and observer viewing direction at each. E.g., the first card locates a task at (x,y) = (13,8.5); viewing direction is north (0 degrees).

SENSORS

This keyword begins in column 1. It is followed by the sensor definitions.

 1

The integer value on this card is the number of sensors to be defined inside the room (interior sensors).

20 15 10 5

This card locates a sensor at the center of the ceiling:

20 15 10 - the (x,y,z) coordinates of the sensor.

5 - the direction (the floor) faced by the sensor.

1

The integer value on this card is the number of sensors to be defined outside the room (exterior sensors).

40 25 8 2

This card locates a sensor above teh northernmost window:

40 25 8 - the (x,y,z) coordinates of the sensor

5 - the direction (north) faced by the sensor.

PROFILE

This keyword begins in column 1. The card is followed by cards describing the daylighting environment.

42.4 83.1 75. 2

The values on this card are:

42.4 - the latitude of the site. A positive latitude is in the northern hemisphere; a negative latitude is in the southern hemisphere.

83.1 - longitude of the site. A positive longitude is in the western hemisphere (west longitude); a negative longitude is in the eastern hemisphere (east longitude).

75. - the longitude at the center of the time zone in which the site lies.

2 - the ID of the weather station from which cloudiness data is to be taken. This means that the station in question is the second in the "cloudiness" database. Refer to Section V for more details on this database.

0 0 0 0 1 1 1 1 1 1 0 0

The twelve integer values on this card constitute the daylight savings time "map". The values correspond chronologically with the months of the year -- a 1 value means daylight savings time is in effect during the month; a 0 value means DST is not in effect. In this case, DST is to prevail during May-October; standard time will be in effect during the remaining months.

0 0 0 0 0 0 0 0 1 1 1 1 0.5 1 1 1 1 0 0 0 0 0 0 0

This card defines the occupancy factors of the room. The twenty-four values correspond to the 24 1-hour periods beginning at midnight; the first value corresponds to 0000 -0100; the second corresponds to 0100-0200, etc. Each value may be in the range 0 - 1. A zero value means the room is unoccupied; a one value means the room is fully occupied. In this case, the room is completely occupied from 0800-1200 and from 1300-1700. It is half-occupied from 1200-1300 and unoccupied during the remaining periods.

DIMMING

This keyword begins in column 1; it is followed by cards which define the luminaire dimming strategy.

1

The integer on this card selects the method of luminaire control:

1 - on/off
2 - high/low/off
3 - continuous dimming

In this example we have selected on/off control.

30. 60.

These are the threshold values which will determine luminaire settings. If the minimum illuminance over the control target area is below 30 fc, teh controlled luminaires will be on. If the minimum illuminance over the control target area is above 60 fc, the controlled luminaires will be off. If the minimum illuminance over the control target area is between 30 and 60 fc, the controlled luminaires will be in the same state (on or off) they were immediately before the minimum illuminance over the control target area entered that range. The range 30 - 60 fc is the "deadband"; the deadband is required to avoid luminaire flickering in the vicinity of a threshold value. Refer to Section IV for a more complete discussion of the function of these threshold control values.

0 0 1 0 0

Each integer value on this card may be thought of as a switch which is either on or off -- 0 = off, 1 = on. Each switch corresponds to one control criterion:

1 - minimum illuminance over the user-defined target points
2 - avarage illuminance over the user-defined target points

3 - minimum illuminance over the control target area
4 - average illuminance over the control target area
5 - minimum ESI over the user-defined target points

One and only one of these switches must be "on"; in this case we have selected switch 3 - minimum illuminance over the control target area.

6 3 16 36 7 15 2.5

This card defines the control target area:

6 3 - the number of columns and rows, respectively, in the control target area.

16 36 - The x-coordinates of the leftmost and rightmost columns in the control target area

7 15 - the y-coordinates of the lower and upper rows in the control target area.

2.5 - the height of the control target area above the floor.

0

The integer on this card gives the number of luminaires which are always off.

1

The integer on this card gives the number of luminaires which are to be controlled.

2 3 6

The integer values on this card (maximum: 10 values) identify the luminaires which are to be controlled. If more than 10 luminaires are to be controlled, use as many cards as required; however, each card except the last must identify exactly 10 luminaires to be controlled.

Note the following:

1. Even though a sensor defined in the SENSORS block may not be used to control luminaires, the same effect may be achieved by defining a control target area of only one point.

2. The sunlight component on external sensors (and all interior points as well) is ignored.

3. For the energy profile, any luminaire can be in one of 3 groups:
   a) always off
   b) controlled
   c) always on

Any luminaire which is not explicitly defined in a) or b) is assumed to be always on.

3.11 Continuous Dimming

We shall leave the room layout the same as in Example 10. The difference is that we want to control the luminaires in such a way that a threshold ESI value is maintained at each target point. Each luminaire can be dimmed independently; our goal is to minimize energy consumption while maintaining at least 30 ESI fc at each of the three task locations.

```
ROOM
EXAMPLE 11 -- ENERGY PROFILE WITH CONTINUOUS DIMMING
CRITERION IS 30 ESI FC AT EACH TASK LOCATION
ALL SIX LUMINAIRES TO BE DIMMED.

  SAME ROOM ENVIRONMENT AS FOR EXAMPLE 10.
  1 1
40 20  30 15  10 5
.5 .5 .5 .5 .2 .8
TASK
KNOWN
 3 2.5
13 8.5 0
30 8.5 0
34.5 15  -90
SENSORS 1
 1
20 15 10  5
 1
40 25 8  2
FENESTRATION
WINDOW
 1 0.80
8 5
 3
4  16 0 3
3  40 4 3
3  40 17 3
BUILDING
  2
-100 0 -35  250 250 45
.6 .6 .6 .6 .2
-30
17 -560 -35  100 300 80
.5 .5 .5 .5 .5
-15
GROUND
 .12
  1
.08  -150 250  -200 -50  -35
FURNITURE
  3
3  13 9.5 2.5  0
```

```
3  30 9.5 2.5  0
3  33.5 15 2.5  -90
PROFILE
 42.4 83.1  75.  2
0 0 0 0 1 1 1 1 1 0 0
0 0 0 0 0 0 0 0 1 1 1 1 0.5 1 1 1 1 0 0 0 0 0 0
LUMINAIRES
HB57
6300.  .85
1.833 3.833 0.5  92
 0.2  -50. 150. -8.
  6
1  10 10 9.5  0 0 0
2  20 10 9.5  0 0 0
3  30 10 9.5  0 0 0
4  10 20 9.5  0 0 0
5  20 20 9.5  0 0 0
6  30 20 9.5  0 0 0
DIMMING
 3
30.
0 0 0 0 1
0 0 0 0 0 0 0
 0
 6
1 2 3 4 5 6
CALCULATE
ESI HOR
P25B
P25T
```

Note the following differences between this data deck and the deck for Example 10:

1. In the LUMINAIRES block the card

   0.2 -50. 150. -8.

   has non-zero values on it for the first time in the examples we have considered. The 0.2 value is the minimum gain (= fraction of light output) to which the luminaire may be dimmed. In this case the luminaire cannot be dimmed below 20% light output. The remaining three numbers on the card are quadratic coefficients a, b, c which relate wattage consumption to gain as follows:

   $$\text{watts} = a \times \text{gain}^2 + b \times \text{gain} + c$$

   In this case we have $a = -50$, $b = 150$, $c = -8$. The watts computed from the above expression at full light output (gain = 1.0) must always equal the watts given for the luminaire, 92 in this case.

2. In the DIMMING block we have specified luminaire control method 3 -- continuous dimming. We have also selected

30 ESI fc minimum as our criterion control value (this is done via the card 0 0 0 0 1). Since the ESI criterion is applied to the target points themselves, we have no use for a control target area and therefore have not defined one (the card 0 0 0 0 0 0 0 specifies 0 rows and 0 columns and therefore no control target area is defined). Also we have specified that all six luminaires are to be under dimming control.

For energy profile calculations, any of the five controlling criteria may be specified, regardless of the luminaire control method selected. The converse is not true, however, for when the criterion is minimum ESI, only continuous dimming may be specified.

3.12 Design Synthesizer

The CEL-1 package contains a design synthesizing feature. This feature is to be used when the user does not know the luminaire locations; rather, he wishes the computer to compute the optimum positioning of luminaires based on design criteria which are input to the program. The design criteria which may be specified are:

1) Minimum horizontal fc at any target point.

   In this case, the goal is to have the horizontal fc at each target point be at least as much as the criterion value.

2) Minimum ESI at any target point.

   The ESI at each target point is to be as least as much as the specified criterion value.

3) Average Horizontal fc over all target points.

   The average horizontal illuminance over all target points is to be no less than the criterion value.

Any one, two, or all three of these criteria may be used on a given CEL-1 execution.

The synthesizer works by selecting a subset of luminaire locations from a target set specified by the user. The idea is that the user's target set contain the optimum set, which the computer then finds. The user specifies the set of luminaires as a rectangular grid of locations which may be modified by a mask which eliminates certain luminaires from the grid of possibilities. Here is an example:

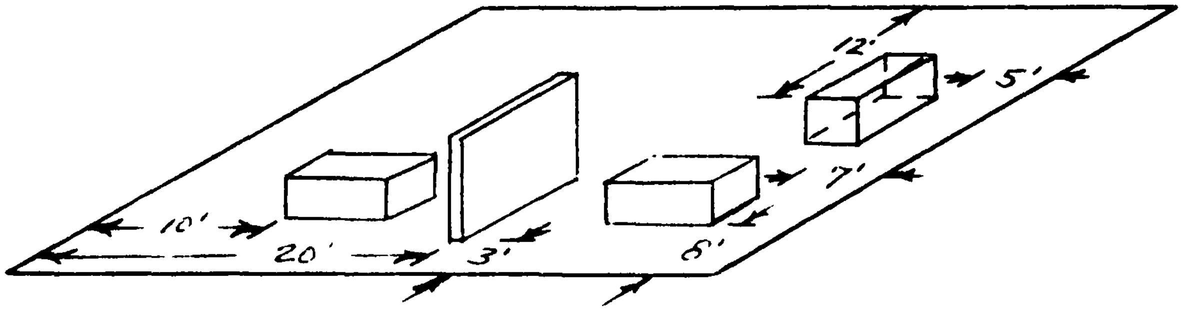

Figure 12a: Room layout for Example 12. Walls and ceiling are not shown. Task locations are on the three desks.

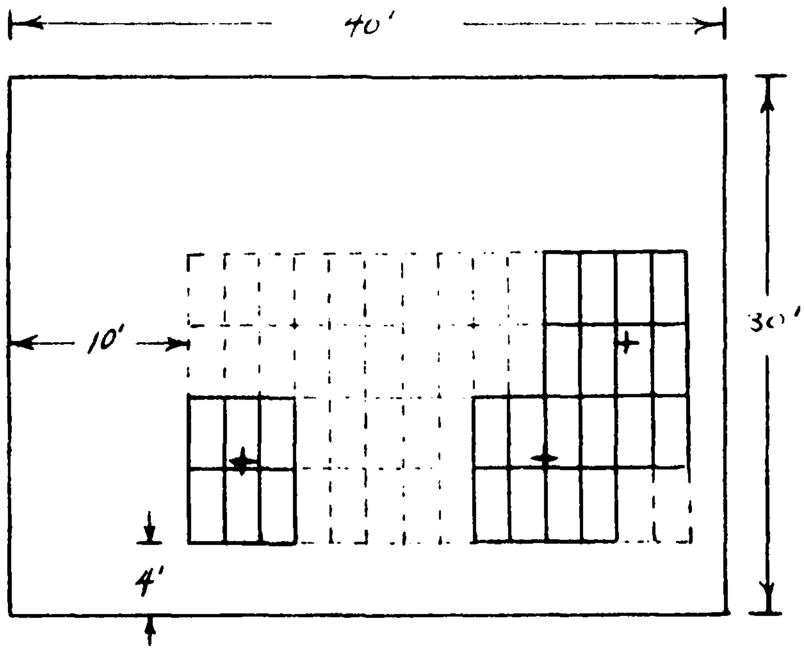

Figure 12b: Possible luminaire locations for Example 12. Locations enclosed by dashed lines are included in rectangular grid but are "masked" out and hence are not candidates for selection by the design synthesizer.

3.12.1 Example 12 - the Design Synthesizer

The room environment and target locations are the same as those for Example 5. The possible luminaire locations we would like to consider are shown in the plan view of Figure 12b. The luminaire is the same one we have used all along, 'HB57'. Our criteria will be:

40 fc minimum at any task location
50 ESI minimum at any task location
75 fc average over all task locations

The data deck will look like this:

```
ROOM
EXAMPLE 12 -  ILLUSTRATING THE DESIGN SYNTHESIZER
3 TASK LOCATIONS (FOR ESI RATING) ON 2.5' HIGH DESKS
TWO ROOM INSERTS,  LUMINAIRE 'HB57', 3150 LUMENS PER LAMP
  LLF = 0.85
CRITERIA:  40 FC MINIMUM, 50 ESI MINIMUM, 75 FC AVERAGE
  1 1
40 20  30 15  10 5
.5 .5 .5 .5 .2 .8
INSERTS
  2
4  0.35  32 36  0 0  0 7
3  .11  40 40  5 17  3 8
TASK
RATING
  3  2.5 1
13 8.5  0
30 8.5  0
34.5 15  -90
FURNITURE
  4
3  13 9.5 2.5  0
3  30 9.5 2.5  0
3  33.5 15 2.5  -90
8  20 9 6  90
DESIGN
HB57
6300. 0.85
1.833 3.833 0.5
 0 0 0
40. 50. 75.
14 4  11 37  6 18  9.5
 0 0 0 0 0 0 0 0 0 0 1 1 1 1
 0 0 0 0 0 0 0 0 0 0 1 1 1 1
 1 1 1 0 0 0 0 0 1 1 1 1 1 1
 1 1 1 0 0 0 0 0 1 1 1 1 0 0
CALCULATE
ESI HOR
P25B
P25T
```

Note that the DESIGN block specifies all necessary luminaire parameters (and that the position of the parameters is very similar to the position in the LUMINAIRES block). Therefore, no LUMINAIRES block is necessary. The cards have meanings described below:

DESIGN

This keyword must begin in column 1. The presence of a DESIGN keyword in the data deck automatically invokes the design synthesizer algorithm in CEL-1.

HB57

This is the name of the file containing the photometric candela data. This name must begin in column 1. Refer to Example 1 for a fuller discussion of photometric files.

6300. 0.85

These are the initial lamp lumens (total of all lamps in the fixture) and the light loss factor, respectively.

1.833 3.833 0.5

This card gives the dimensions of the luminaire -- width, length, and height, in that order. The width and length are the width and legnth of the luminous opening of the luminaire. Refer to the discussion of Example 1 for the precise definition of width and length.

0 0 0

These are, respectively, the bearing, tilt, and cant angles of the luminaires -- these angles are discussed in more detail in Example 1. Basically, all zero values in these fields means that the luminaires are not to be rotated or tilted.

40. 50. 75.

This card defines the design criteria values:

40. - The horizontal illuminance at each task location is to be at least 40 fc.

50. - The ESI Rating at each task location is to be at least 50.

75. - The average horizontal illuminance over all task locations is to be at least 75 fc.

A zero value for any of the three criteria means that that particular constraint will not be applied. E.g., if the card values were 0. 50. 75., then the synthesis algorithm would operate with no lower limit on the horizontal illuminance at any task location. Note that at least one nonzero value must be specified -- else there are no criteria for the synthesizing logic to use.

14 4 11 37 6 18 9.5

This card defines a rectangular grid which locates the center of each luminaire which is to be a candidate for selection by the synthesizer. The entries on the card have the following meanings:

14 - the number of columns of luminaires in the grid.

4 - the number of rows of luminaires in the grid.

11 37 - the x-coordinates of the leftmost and rightmost columns of luminaires in the grid.

6 18 - the y-coordinates of the lower and upper rows of luminaires in the grid.

9.5 - the z-coordinate of the luminous opening of the luminaires.

Note that the coordinates defining the luminaire grid give the locations of the luminaire centers. In this case, a 2' by 4' grid is defined.

```
0 0 0 0 0 0 0 0 0 1 1 1 1
0 0 0 0 0 0 0 0 0 1 1 1 1
1 1 1 0 0 0 0 0 1 1 1 1 1
1 1 1 0 0 0 0 0 1 1 1 1 0 0
```

These cards constitute the "mask" which modifies the rectangular grid defined in the previous card. The mask must be all integer values and each integer must be either 0 or 1. There is one card for each row in the grid; each card has a number of values on it equal to the number of columns in the grid. Hence the values correspond one-for-one with the grid locations; the first card in the deck "masks" the top row of the grid, etc. A 1 value means that the corresponding luminaire is to be included in the set of possible luminaire locations from which the design synthesizer selects the optimum subset. A zero value means that the corresponding luminaire is to be omitted from the set of possible luminaire locations.

Note the following points:

1. The maximum number of luminaires which may be specified in the set of possiblities is 100. Within this limit, any number of rows and columns are permissible (for example, 25 rows of 4 luminaires each). However, a maximum of 40 masking values may be given on any *one card*; in effect, this limits the number of columns to 40 or fewer. The grid size may be larger than 100 if sufficient luminaires are masked out to bring the total down to 100 or fewer. E.g., a 12 x 12 (=144 luminaires) grid may be specified provided the masking cards eliminate at least 44 luminaires from the grid.

2. If it is desired to retain all luminaires in the rectangular grid, then the masking cards will contain all 1 values.

3. If ESI Ratings are to be computed (i.e., the keyword RATING defines the task locations), then the minimum ESI criterion is applied to the ESI Rating and not to any individual ESI value. In all other cases, the ESI criterion is applied to the ESI value which is computed at each point.

4. All luminaires will be oriented in the same fashion. i.e., it is not possible to rotate one luminaire 90 degrees while a second is rotated 180 degrees, etc.

5. The design synthesizer algorithm operates in the absence of daylight; i.e., no fenestration is allowed.

SECTION IV

Input Data Deck Reference Material

4.1 Capabilities

Lighting metrics which may be calculated by the CEL-1 package include:

Illuminance (with or without body shadow)
Equivalent Sphere Illuminance (ESI)
Task Luminance
Background Luminance
Contrast Rendering Factor (CRF)
Lighting Effectiveness Factor (LEF)
Luminance on room surfaces
Illuminance on room surfaces
Visual Comfort Probability (VCP)
Character contour plots

The package permits the luminous environment to have the following characteristics:

1) Luminaires may take on any orientation desired.
2) Rooms are assumed to be rectangular in shape, with ceiling parallel to floor and opposite walls parallel.
3) "Inserts" (areas on a given room surface with reflectance different from that of the whole surface) may be present.
4) Physical obstructions, such as furniture and partitions, may be present in the space.
5) Several types of fenestration are allowed, permitting daylight to enter the space.
6) The external environment (other buildings' location and reflectance) may be specified.

In addition to the lighting metrics which may be calculated, the CEL-1 package includes an energy profile capability and a design synthesis capability. The energy profile feature permits the user to evaluate the energy-use consequences of automatically controlling the light output of luminaires according to the daylight which is present. An hour-by-hour profile is computed for a typical day in each month of the year.

The design synthesizer selects from among a set of user-specified possible luminaire locations the subset which minimizes the quantity required to satisfy the user's design criteria. This design synthesis process ignores any daylight which may be present.

4.2 Input Data Conventions

CEL-1 analysis is performed on a rectangular room. The walls of the room are designated to correspond to the four major compass directions; thus when we speak of "room north" we mean north relative to the wall designations we have chosen (in general, room north will not coincide with true north). The room surfaces are numbered as follows

1 - west wall
2 - north wall
3 - east wall
4 - south wall
5 - floor
6 - ceiling

In general, this directional numbering scheme is followed for any direction-related input, such as faces of buildings, surfaces of sawtooth monitors, etc.

A rectangular coordinate system is established with its axes parallel to the room surfaces and its (0,0,0) origin located at the southwest corner of the floor. The positive x-direction is room east; positive y-direction is room north; the positive z-direction is straight up (zenith). All (x,y,z) locations required by CEL-1 must be given relative to this coordinate system.

Angles are used to specify the viewing directions for ESI and VCP calculations. Angles are also used to specify the orientation of luminaires. The reference 0° angle is room north; positive angles are obtained by moving clockwise from room north, while negative angles are obtained by moving counter-clockwise from room north. In general, any negative angle may be equivalently represented by adding 360° to its negative representation. For example, room west may be specified as either -90° or 270°.

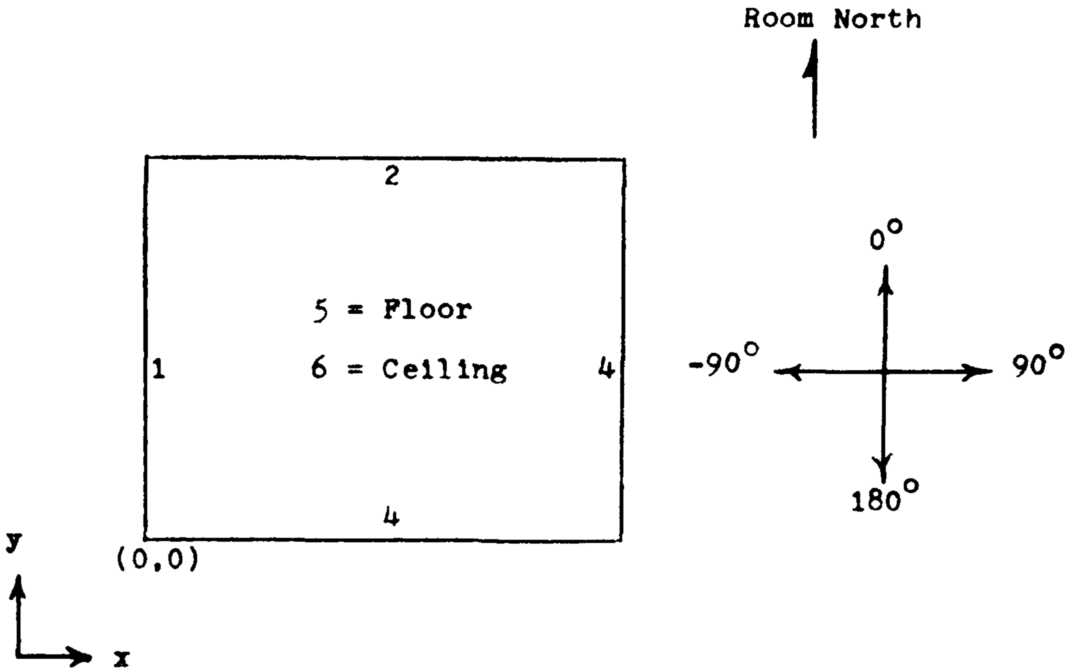

Figure 13: Top view of room, showing room surface numbering scheme, coordinate directions and origin, and specification of angles.

So that the CEL-1 input stream will present as little mystery to the user as possible, the input data is presented in block-modular form. A "block" is a section of the input which contains only a small subset of the total input; this subset will be restricted to describing only a certain aspect of the luminous environment. For example, windows are defined in the FENESTRATION block, while luminaires are defined in the LUMINAIRES block. Each block (except the first) is preceded by an alphabetic keyword; this makes it easier for the user to "read" the input stream.

Some input blocks are always required; others are optional, depending upon which CEL-1 capabilities the user wishes to invoke. Whichever blocks are present in the input data deck, they must appear in a prescribed order. The following table lists the input blocks in the order they must appear. The notation beneath each program may be interpreted as follows:

* - required input block
O - optional input block
(no entry) - block is forbidden

The "capability set" refers to the CEL-1 capabilities being used, as follows:
A - No furniture, no daylight, unknown task loc'ns
B - Furniture, no daylight, any tasks
C - Design Synthesizer
D - Daylight, either analysis or profile mode

	capability set			
Block	A	B	C	D
ROOM	*	*	*	*
INSERTS	O	O	O	O
TASK	*	*	*	*
SENSORS				O
FENESTRATION				*
FURNITURE		O	O	O
PROFILE				O
ANALYSIS				O
LUMINAIRES	*	*		*
DIMMING				*
DESIGN			*	
CALCULATE	*	*	*	*

Data elements in the input stream will consist of three types:

a) alphabetic - these will be text ID lines, keywords, and file names. The latter two will have rigid column aignment requirements for their location on the line.

b) 'real' numeric - these may take on fractional values, if necessary. They may be entered with or without a decimal point. Their placement on the input line is not subject to rigid column-alignment requirements, but each pair of numeric values must be separated by a comma and/or one or more spaces.

c) 'integer' numeric - these may not take on fractional values and must be coded in the input stream without a decimal point. No rigid column-alignment rules apply, but each pair of numeric values must be separated by a comma and/or one or more spaces

In the following discussions of the input blocks, numeric input values are 'real' unless explicitly identified as 'integer'.

4.3 ROOM block

The ROOM block must be present in the input stream for all four CEL-1 programs. The ROOM block is as follows:

```
<text ID line 1>
<text ID line 2>
<text ID line 3>
<text ID line 4>
<text ID line 5>
<units definition>
<room dimensions>
<room surface reflectances>
```

These lines take the following forms:

<text ID line x> - Each of these five lines may contain up to 80 characters of text which serves to identify the printed results. The contents of these lines are for identification purposes only and in no way influence the computations.

<units definition> - this line contains the two integer values:
<input units> <output units>

where

<input units> = 1 if all dimensions, distances, etc., are given in feet.
= 2 if all dimensions, distances, etc., are given in meters.

<output units> = 1 if output values are to be in English units. In this case, computed luminance values will be given in footlamberts; computed illuminance values will be in footcandles.

2 if output values are to be in metric units. In this case, computed luminance values will be given in candelas per square meter; computed illuminance values will be in lux.

<room dimensions> - This line contains the six real values:
<E-W dimension> <E-W discretization> <N-S dimension> <N-S discretization> <height> <height discretization>

where

<E-W dimension> is the east-west dimension of the room (the distance between walls measured in the x-direction)

<E-W discretization> is the number of zones into which the x-dimension of room surfaces are to be divided

<N-S dimension> is the north-south dimension of the room (the distance between walls measured in the y-direction)

<N-S discretization> is the number of zones into which the y-dimension of room surfaces are to be divided

<height> is the ceiling height above the floor

<height discretization> is the number of zones into which the z-dimension of room surfaces are to be divided

<room reflectances> contains the six real values defining the reflectances of the room surfaces:

<refl 1> <refl 2> <refl 3> <refl 4> <refl 5> <refl 6>

where

<refl 1> is the reflectance of the west wall
<refl 2> is the reflectance of the north wall
etc.

4.4 INSERTS block

This block is always optional when running CEL-1. It is used to define portions of the room surfaces which have reflectances differing from those of the surface as a whole. The form of the INSERTS block is:

INSERTS

<# inserts>

<insert definition 1>

<insert definition 2>

.
.
.

<insert definition m>

These lines are defined as follows:

<# inserts> is an integer giving the number of inserts to be placed on the room surfaces. A maximum of 10 inserts may be specified. If no inserts are to be defined, this block must be omitted from the input stream.

<insert definition x> defines the x'th insert as follows:

<surface #> <reflectance> <x-low> <x-high> <y-low> <y-high> <z-low> <z-high>

where

<surface #> is an integer identifying the surface on which the insert lies.

<reflectance> is the reflectance of the insert.

<x-low> is the lower x-coordinate of the insert.

<x-high> is the higher x-coordinate of the insert.

<y-low> is the lower y-coordinate of the insert.

<y-high> is the higher y-coordinate of the insert.

<z-low> is the lower z-coordinate of the insert.

<z-high> is the higher z-coordinate of the insert.

Note that one of the three coordinate pairs will always have two identical values; e.g., for any insert on the east wall, <x-low> = <x-high>

4.5 TASK block

The TASK block specifies the locations within the room at which the illumination metrics are to be calculated. This block is composed of one of three sub-blocks:

4.5.1 RATING sub-block

This sub-block is used to specify task locations for which ESI Ratings are to be calculated. Each task location is specified individually (rather than as part of a rectangular grid). Also, a primary viewing direction is specified. Each such task location actually results in calculations being performed at 8 different target points.

The user-specified task location is taken to be the location of point A (see figure 13); the remaining 7 points are positioned relative to point A as shown. Two options are allowed for the viewing directions to be used at the 8 points. These are:

VIEWING DIRECTION FOR ESI CALCULATIONS

Point	Option 1 (IES)	Option 2 (Navy)
A	Primary	Primary
B	Primary - 45	Primary - 45
C	Primary + 45	Primary + 45
D	Primary	Primary - 22.5
E	Primary	Primary + 22.5
F	Primary	Primary
G	Primary - 45	Primary - 22.5
H	Primary + 45	Primary + 22.5

In the chart above, positive angular displacement is clockwise, while negative angular displacement is counter-clockwise.

The ESI Rating is computed by first calculating the ESI at each of the 8 points A thru H. The ESI Rating is then:

$$\text{ESI Rating} = \exp(\ln ESI_A + \ln ESI_B + \ldots + \ln ESI_H)/8)$$

(exp is the exponential function; ln is natural logarithm)

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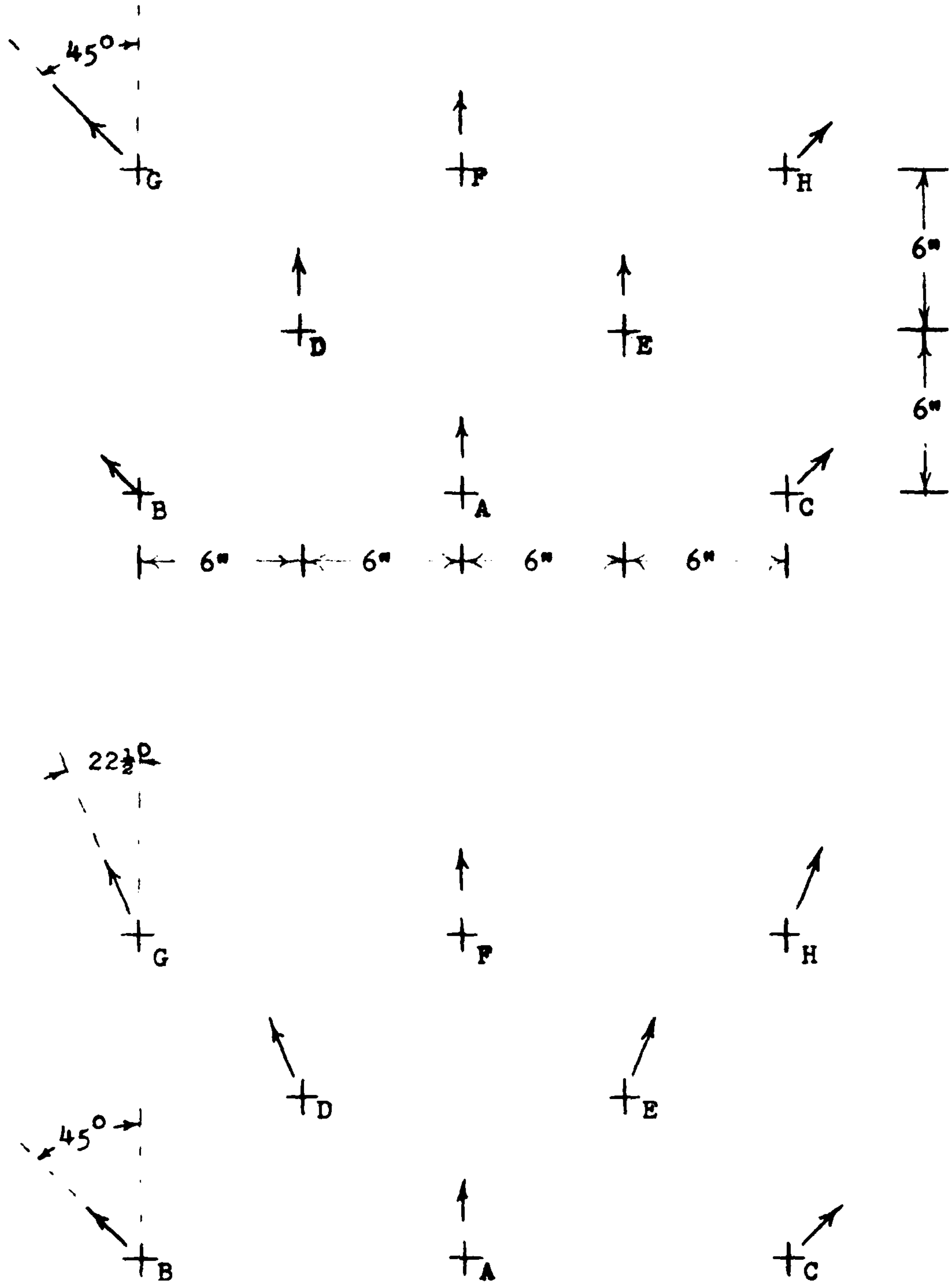


Figure 14: Task locations for ESI Rating Calculations. Arrows indicate viewing directions; top sketch is IES option; bottom sketch is Navy option.

The format of the RATING sub-block is:

```
RATING
<# locations>  <z>  <option>
<x>  <y>  <primary view>  \
   .                       |
   .                       > repeat for each task location
   .                       |
<x>  <y>  <primary view>  /
```

where

<# locations> is an integer which gives the number of task locations (range: 1-50).

<z> is the z-coordinate (height above the floor) at each task location.

<option> is either 1 or 2 and defines the secondary viewing directions to be used (refer to "Task Locations") as follows:

= 1 for IES option
= 2 for Navy option

<x> <y> are the (x,y) coordinates of the task location.

<primary view> is the primary viewing direction at this task location.

Example:

```
RATING
 4 2.5  1
2 2 0
2 20 0
16 2 90
16 20 -90
```

Four task locations are specified for ESI Rating calculations; all are 2.5' above the floor. Primary viewing directions are:
  north at (2,2,2.5) and (2,20,2.5)
  east at (16,2,2.5)
  west at (16,20,2.5)
Secondary viewing directions are determined using the IES option.

4.5.2 UNKNOWN sub-block

This sub-block defines a rectangular grid of target points: its format is:

```
UNKNOWN
<# columns>  <# rows>  <xl>  <xr>  <yb>  <yt>  <z>   <eye>
<# viewing directions>
<view 1>  <view 2>  <view 3>  <view 4>
```

where

<# columns> is the number of columns of target points. The maximum number of columns is 21 if all three of the following conditions hold:

1. No obstructions are defined in the room.
2. No fenestration is defined (i.e., no daylight).
3. The design synthesizer is not being used.

In all other cases the maximum number of columns is 10.

<# rows> is the number of rows of target points. The maximum number of rows is either 21 or 10, based on the same conditions which limit the number of columns.

<xl> is the x-coordinate of the leftmost column of target points.

<xr> is the x-coordinate of the rightmost column of target pts.

<yb> is the y-coordinate of the bottom row of target points.

<yt> is the y-coordinate of the top row of target points.

<z> is the z-coordinate of the target points (= height above the floor).

<eye> is the observer eye height for VCP calculations.

<# viewing directions> is an integer (range: 0-4) specifying the number of viewing directions. Zero may be specified only when the only metric being calculated is horizontal fc (no body shadow).

<view i> is the i'th viewing direction (in degrees). 0 = north, -90 = west, etc. There is no line specifying viewing directions if the <# viewing directions> is given as zero.

Consider the following example:

```
UNKNOWN
15 19  2 30  2 38  2.5  4
  4
0 90 180 -90
```

This example specifies a grid of target points which has

15 columns and 19 rows. All target points are 2.5 feet above the floor. x-coordinates are 2, 4, 6, ... , 30. y-coordinates are 2, 4, 6, ... , 38. Four viewing directions are specified: north, east, south, and west, in that order.

The observer eye height for VCP calculations is 4 feet above the floor. Note that even if VCP is not being calculated CEL-1 expects to find a value for <eye> . If VCP is not being calculated, the value for <eye> may be any number, since it will be ignored by the program.

4.5.3 KNOWN sub-block

This sub-block defines target locations individually. One view direction is associated with each target location. This sub-block differs from the RATING sub-block in that no ESI ratings are computed and each defined location is not exploded into 8 points. The format of the sub-block is:

```
KNOWN
<# locations>  <z>
<x>  <y>  <view>  \
   .               |
   .               > repeat for each task location
   .               |
<x>  <y>  <view>  /
```

where

<# locations> is an integer (range: 1-400) specifying how many task locations are to be defined.

<z> is the z-coordinate (height above the floor) of all task locations.

<x> <y> are the (x,y) coordinates of the task location.

<view> is the viewing direction (degrees) at this task location.

Example:

```
KNOWN
 4 2.5
2 2 0
2 20 0
16 2 90
16 20 270
```

Four task locations are specified, all 2.5' above the floor. Viewing direction is north for task locations at (2,2,2.5) and (2.20.2.5). View direction is east at (16,2,2.5), and west at (16.20.2.5).

4.6 SENSORS block

This block defines the locations of sensors at which illuminance is to be calculated. This block is optional when the daylight capabilities of CEL-1 are being used; the block must be omitted in all other cases.

A "sensor" is a location where illuminance is to be calculated (not a task location). Sensors may be located either inside the room or outside the object building. Illuminance computed on interior sensors is the aggregate effect of both daylight and luminaires; illuminance computed on exterior sensors is the result of daylight alone. The illuminance values calculated are for informational purposes only and do not influence the dimming of luminaires in any way. It is hoped that by correlating sensor illuminance with the calculated metrics at the task locations, the user can effectively determine where real-world sensors which actually control luminaires should be located. The form of the Sensors block is:

```
SENSORS
<# interior sensors>
<interior sensor def'n 1>
<interior sensor def'n 2>
    .
    .
    .

<interior sensor def'n m>
<# exterior sensors>
<exterior sensor def'n 1>
<exterior sensor def'n 2>
    .
    .
    .

<exterior sensor def'n n>
```

These input lines are defined as follows:

<# interior sensors> is an integer value (range: 0-10) which gives the number of sensors within the room.

<interior sensor def'n x> defines the location and orientation of the x'th interior sensor (no lines of this type are present if zero interior sensors are specified). The form of each line is:

```
<x>  <y>  <z>  <orientation>
```

where

<x> <y> <z> are the (x,y.z) coordinates of the sensor location

<orientation> is one of the integer values 5 or 6:
5 - the sensor faces the floor
6 - the sensor faces the ceiling

<# exterior sensors> is an integer value (range: 0-10) which gives the number of sensors which are located outside the room.

<exterior sensor definition x> defines the location and orientation of the x'th exterior sensor. If the number of exterior sensors is specified as zero then no lines of this type will be present.) The format of each such line is:

<x> <y> <z> <orientation>
where
<x> <y> <z> are the (x,y,z) coordinates of the sensor location on the object building exterior.

<orientation> is an integer value (range: 1-6) which defines the direction faced by the sensor:
1 - sensor faces west
2 - sensor faces north
3 - sensor faces east
4 - sensor faces south
5 - sensor faces the ground (nadir)
6 - sensor faces the sky (zenith)

Sensors may be located anywhere outside the room; e.g., the user may wish to position a sensor just beneath a window overhang. Since sensor illuminance is computed from daylight only, care must be taken that the sensor is not smothered by the object building; e.g., a sensor on the north wall should not face south, etc. Consider the following example of a Sensors input block:

```
SENSORS
 2
10 5 2.5  6
10 5 10   5
  1
-.5 8 5   2
```

This block defines 2 interior sensors:
a) located at (x,y,z) = (10.5,2.5) facing the ceiling
b) located at (x,y,z) = (10.5,10) facing the floor
and one exterior sensor:
a) located at (x,y,z) = (-0.5,8,5) facing north. Note that this sensor is one-half foot outside the west wall.

4.7 FENESTRATION block

The fenestration block in the input stream is used to define sources of daylight which may enter the room. This block must be included in the input deck when using the daylight capabilities of CEL-1; it is not used at any other time. The block is composed of sub-blocks, each headed by its own keyword, which define the daylighting environment. These sub-blocks are:

WINDOW	- defines windows
CLERESTORY	- defines clerestory structures
SAWTOOTH	- defines sawtooth monitors
SKYLIGHT	- defines skylights
BUILDING	- defines building containing the room and any other buildings in the neighborhood
GROUND	- defines reflectance of ground and extent and reflectance of ground inserts

Of these sub-blocks, BUILDING and GROUND are always required. Further, at least one of the other sub-blocks must be present, and any of them may be repeated more than once if necessary. The limits are as follows:

$$\left.\begin{array}{l}\text{WINDOW}\\ \text{CLERESTORY}\\ \text{SAWTOOTH}\\ \text{SKYLIGHT}\end{array}\right\}\ \begin{array}{l}\text{The sum of the number of these sub-blocks}\\ \text{must not exceed 10.}\end{array}$$

BUILDING and GROUND are present exactly once each. Each of the four sub-blocks WINDOW, CLERESTORY, SAWTOOTH, and SKYLIGHT specify one or more fenestration source elements (e.g., one window = 1 fenestration source element). The total number of fenestration source elements specified may not exceed 50.

The following sections define the sub-block details.

4.7.1 WINDOW sub-block

Each window in the room and its associated parameters is specified in a WINDOW sub-block. Parameters which are present with all windows are listed following the WINDOW keyword. Parameters which are optional, such as pull-down shades, are preceded by other keywords. The various groups of parameters are discussed below:

```
WINDOW
<glaze>  <transmittance>
<width>  <height>
<# locations>
<surface>  <x>  <y>  <z>
    .
```

.
.

<surface> <x> <y> <z>

The inputs listed above are required for each window type in the room. Two windows are of the same "type" only if all the characteristics in the above inputs are identical in each window. Detailed definitions of the items given in the above inputs are:

<glaze> is an integer value:
1 - window glazing is clear (image-preserving)
2 - window glazing is diffusing (opaque)

<transmittance> is the transmittance of the glazing (range: 0 thru 1)

<width> is the width of the window opening on the inside wall.

<height> is the height of the window opening on the inside wall.

<# locations> is the number of windows with these characteristics on any of the room walls. This is an integer value which must be at least one. For each window location specified here, one line of the form

<surface> <x> <y> <z>

will be present. Details are:

<surface> is an integer (range: 1-4) which tells which wall the window is on. 1 = west wall, 2 = north wall, 3 = east wall. 4 = south wall.

<x> <y> <z> are the (x,y,z) coordinates of that corner of the window opening which is nearest the room origin. For example, a window on the north wall begins 10' from the west wall and 3' from the floor; the room is 20' wide (E-W) and 30' long (N-S). Then
<x> <y> <z> = 10 30 3

4.7.1.1 Shades

Pull-down shades may be specified for any window. This is done by including in the input stream the keyword SHADE followed by one line of parameters:

SHADE
<transmittance> <depth>

where

<transmittance> gives the transmittance of the shade (range: 0-1).

<depth> gives the distance from the top of the window opening to the bottom of the shade. I.e., this is the amount of window (measured from the top) which is covered by shade.

Note that a shade is assumed to be diffusing (opaque) and that it is assumed to extend all the way across the window. The SHADE keyword and parameters apply to all locations of the WINDOW definition to which it applies.

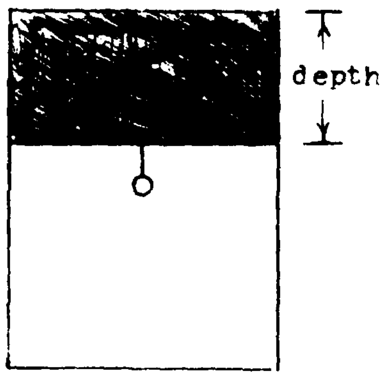


Figure 15: Definition of a window shade.

4.7.1.2 Drapes

Drapes may be specified for any window. Drapes may extend from either or both sides of the window opening toward the center of the window. To include drapes in the calculations, the following lines are coded as part of the WINDOW sub-block:

DRAPE
<transmittance> <distance 1> <distance 2>

where

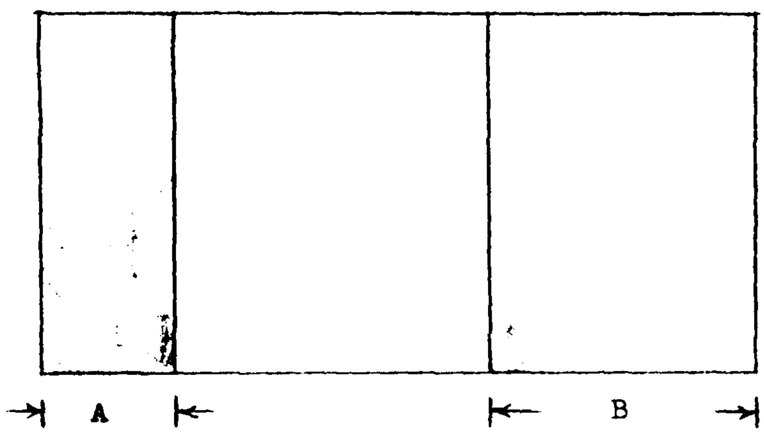
<transmittance> is the transmittance (range: 0-1) of the drape material.

<distance 1> is the distance from the left edge of the window to the edge of the drape.

<distance 2> is the distance from the right edge of the window to the edge of the drape.

"Left" and "right" edges are determined by viewing the window from inside the room. If the drapes extend from one edge of the window only, then <distance 1> or <distance 2> will be equal to zero.

Note that drapes are assumed to be diffusing (opaque) and are assumed to extend the entire height of the window opening. The DRAPE specification applies to all locations of the WINDOW definition which it follows.



A = distance 1
B = distance 2

Figure 16: Definition of window drapes. View is from inside room looking out.

4.7.1.3 Blinds

Blinds may be specified for any window, and the blinds may extend either vertically or horizontally. Blinds are specified as follows:

BLINDS
<type> <thickness> <width> <spacing> <angle> <reflectance>

where

<type> = 1 for blinds extending horizontally
= 2 for blinds extending vertically

<thickness> is the thickness of one vane. If each vane is curved in cross-section, this value should be the thickness of the smallest rectangular cross-section which would completely enclose the vane.

<width> is the width of one vane

<spacing> is the spacing from the center of a vane to the center of an adjacent vane.

<angle> is the angle of closure of the blinds, in degrees. Figure 17 depicts the closure of horizontal blinds. For vertical blinds the closure angle may be in the range (-180 , +180) and is derived as follows: Determine the direction obtained by traveling parallel to one blind vane from inside to outside the room. The closure angle is then the angular displacement from room north to this direction. For example, if we look parallel to a vane on the south wall and we look exactly southwest, then the closure angle is -135 degrees.

If the closure angle is given as 1000, this means that the blinds have variable closure angle. In this case, CEL-1 will attempt to compute daylight effects with the blinds closed just enough to completely protect the room from direct sunlight. Note that this feature is valid only when an energy profile is being calculated; a precise blinds closure angle must be specified when running in analysis mode.

<reflectance> is the reflectance of the blinds material.

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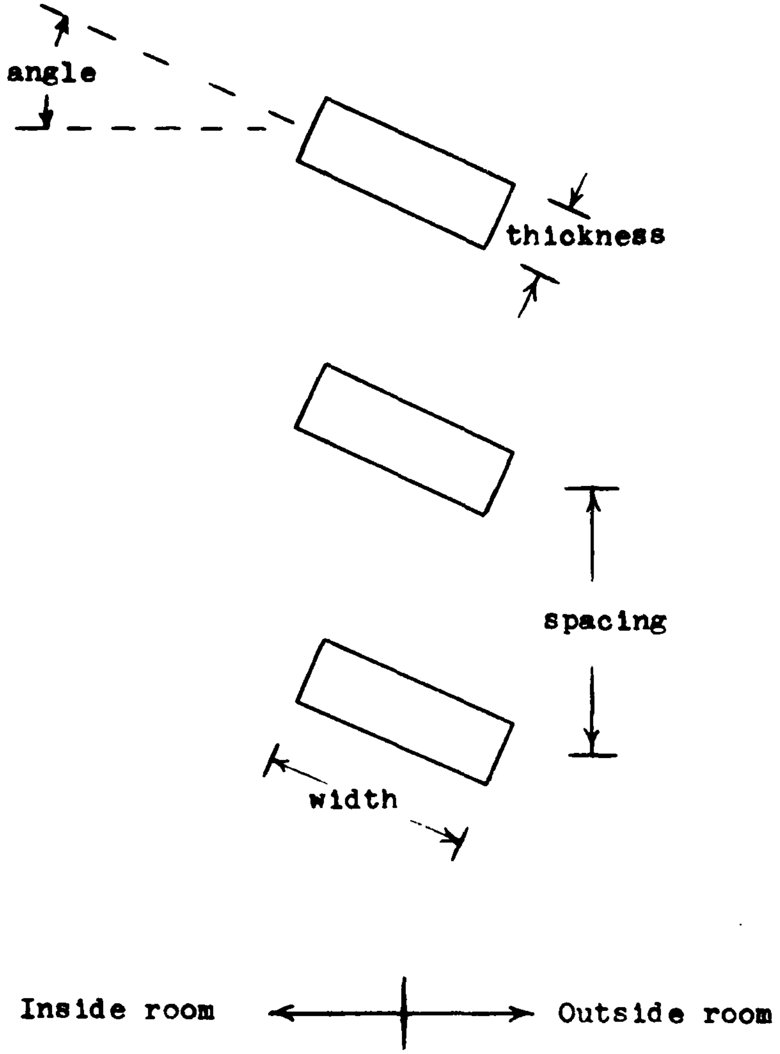


Figure 17: Cross-sectional view of window blinds.

4.7.1.4 Light Shelves

A "shelf" may be specified with a window. A shelf is a plane which protrudes horizontally from beneath a window -- its purpose is to block a portion of the daylight through the window from striking at least a portion of the target plane. Specify a shelf as follows:

SHELF
<depth> <protrusion> <reflectance>

where

<depth> is the shelf's distance beneath the bottom of the window opening.

<protrusion> is the distance the shelf protrudes from the wall which contains the window.

<reflectance> is the reflectance of the shelf.

The shelf will be present for each window location defined in the WINDOW sub-block in which the SHELF specification occurs.

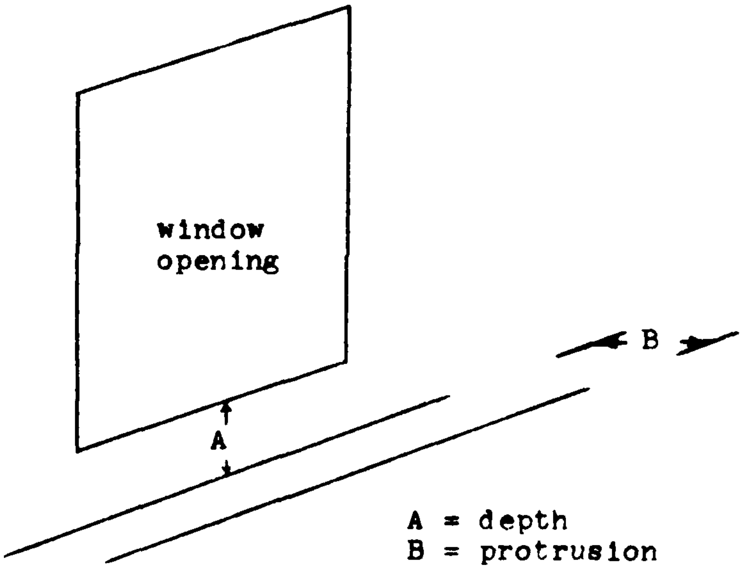


Figure 18: A light shelf beneath a window. View is from inside room.

4.7.1.5 Barriers

A barrier is an obstructing plane on the exterior of a window. Each window may have zero to four barrier planes on its exterior. A barrier may be thought of as an overhang, or a vertical slab outside the window, or as a well wall if the window is recessed, etc.

To visualize window barriers, imagine that the window is being viewed from outside the room. Then a window's barriers are specified this way:

```
BARRIERS
<distance>  <limit 1>  <limit 2>  <protrusion>  <reflectance>
<distance>  <limit 1>  <limit 2>  <protrusion>  <reflectance>
<distance>  <limit 1>  <limit 2>  <protrusion>  <reflectance>
<distance>  <limit 1>  <limit 2>  <protrusion>  <reflectance>
```

where

<distance> is the distance from the window edge in question to the barrier plane. A positive distance means that some portion of wall separates the barrier from the window edge. A zero distance means that the barrier is flush with the window edge. A negative distance means that the barrier obscures some portion of the window surface. (This assumes an observer an infinite distance outside the window looking normal to the window)
An example of a negative distance would be a sloping overhang which slopes from the top of the window downward so that its forward edge is beneath the top of the window.

<limit 1> a) for horizontal barriers (barriers # 2 and # 4), this is the distance from the left extremity of the barrier to the left edge of the window opening. A positive <limit 1> value means that the barrier extends to the left of the window opening; a negative <limit 1> means that the barrier does not extend to the left edge of the window opening.

b) for vertical barriers (barriers # 1 and # 3), this is the distance from the bottom extremity of the barrier to the bottom edge of the window. A positive <limit 1> value means that the barrier extends below the window edge; a negative <limit 1> value means that the barrier does not extend below the window edge.

<limit 2> a) for horizontal barriers (barriers # 2 and # 4), this is the distance from the right extremity of the barrier to the right edge of the window opening. A positive <limit 2> value means that the barrier extends to the right of the window opening; a negative <limit 2> means that the the barrier does not extend to the right of the window opening.

b) for vertical barriers (barriers # 1 and # 3), this is the distance from the top extremity of the barrier to the top edge of the window. A positive <limit 2> value means that the barrier extends above the window edge; a negative <limit 2> value means that the barrier does not extend above the window edge.

<protrusion> is the distance which the barrier protrudes from the exterior wall. This value cannot be negative.

<reflectance> is the reflectance (range: 0-1) of the barrier surface which faces the window opening.

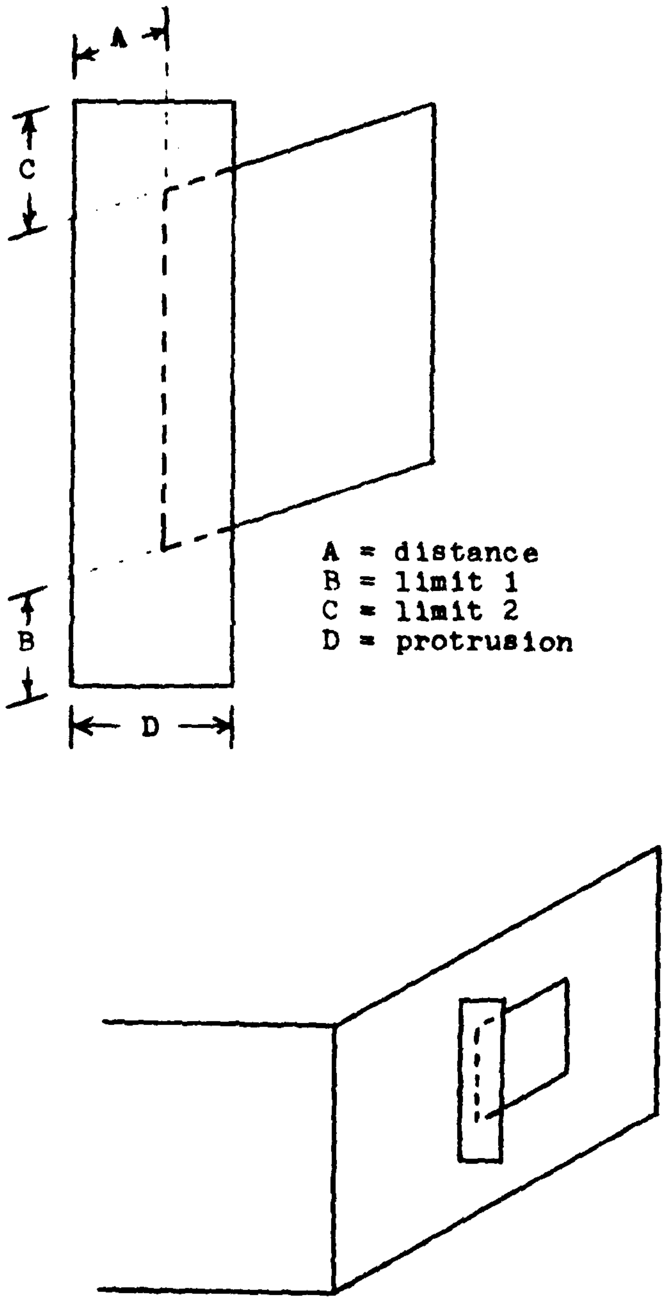
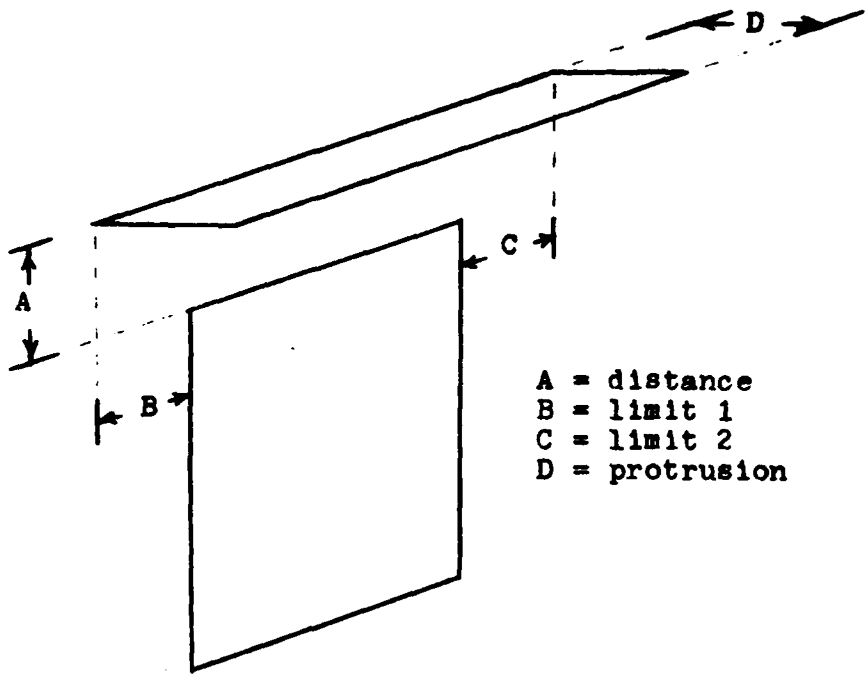


Figure 19: Barrier # 1. Barrier is lightly shaded. Bottom sketch is outside view of wall from a distance. Top sketch is close-up view. Remember that barriers are always perpendicular to the wall.



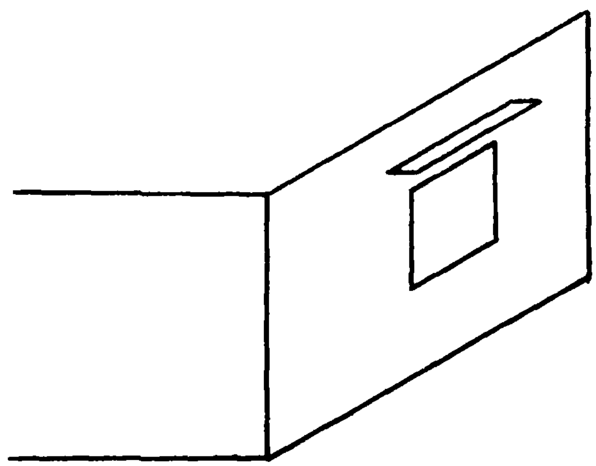
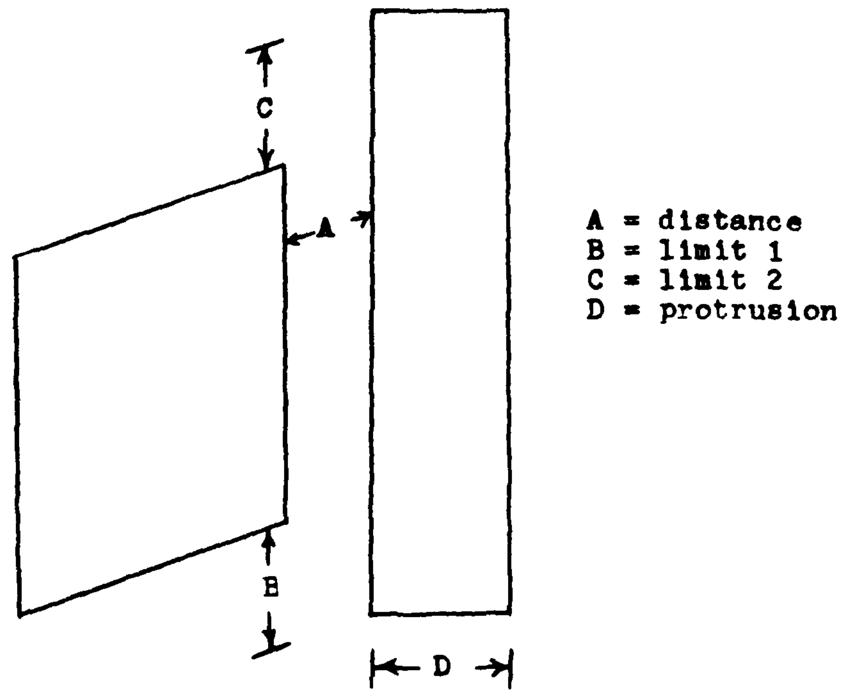


Figure 20 : Barrier # 2 (overhang). Bottom sketch is outside view of wall from a distance. Top sketch is a close-up view. Remember that barriers are always perpendicular to the wall.



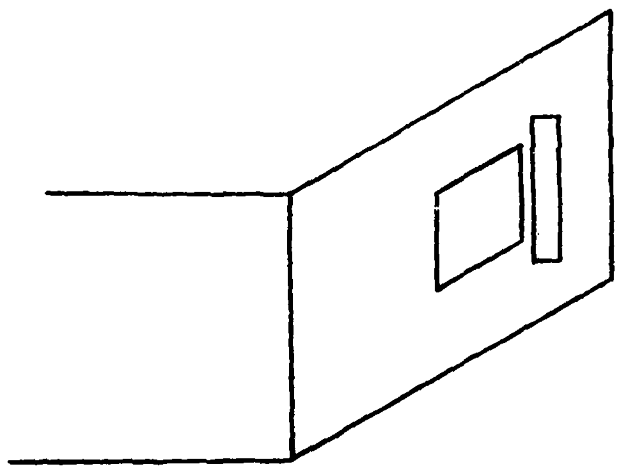


Figure 21: Barrier # 3. Bottom sketch is outside view of wall from a distance. Top sketch is close-up view. Remember that barriers are always perpendicular to the wall.

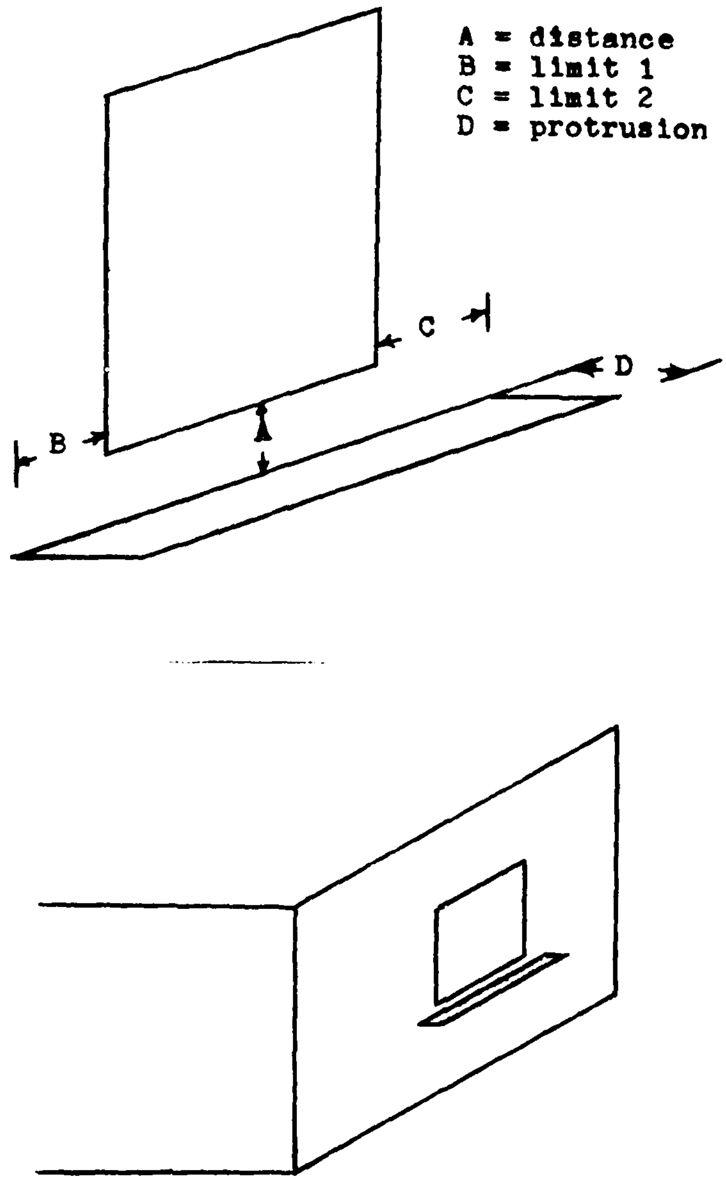


Figure 22 : Barrier # 4. Bottom sketch is outside view of wall from a distance. Top sketch is a close-up view. Remember that barriers are always perpendicular to the wall.

Note that exactly four lines of barrier definition lines are required; this is one line for each of the four possible barriers outside any window. These four barriers are numbered as shown in Figs. 19 - 22; the numbering scheme is based on viewing the window from the outside. The following considerations apply to barrier definitions:

1. If a given window edge has no barrier enter five zero values on the appropriate line.

2. The walls of the room are assumed to be infinitely thin planes. Therefore, if a window opening is recessed within a wall, this situation may be simulated by defining the walls of the recessed well as barriers with a protrusion distance equal to the wall thickness.

3. If a window opening is recessed within a wall and bona fide barriers are present as well but the barriers are not merely extensions of the recessed well, then the user must apply his judgment, for he can only define one barrier per window edge. The recommended approach is to define the barriers to be the well walls, but with a protrusion distance somewhat less than the sum of the actual barrier protrusion plus the wall thickness.

4. It may happen that the dimensions of a recessed window opening do not coincide with the dimensions of the glazing surface which is exposed to daylight. For example, suppose that the window opening is 4' x 5' on the inside wall, but that the size of the gla-covered window itself is only 3' x 3'. In this case the dimensions of the window should be entered as 4' x 5' and the recessed well walls should be defined as barriers -- this is just as previous discussion has indicated. The actual size of glazing is represented in the transmittance value which is entered:

   transmittance entered = (actual transmittance) x (area of glazing) / (area of window opening)

If the actual transmittance is .90 in this case, then the value entered should be

$$0.405 = (.90) \times (9) / (20)$$

4.7.1.6 Summary of WINDOW sub-block

A window sub-block consists of a mandatory window opening definition, followed by one or more optional specifications of shades, blinds, etc. The only restriction governing the optional specifications is that drapes, shades, and blinds are all mutually exclusive on any given window. For example, blinds, barriers, and a shelf may all be present simultaneously for a given window; however, the presence of the blinds precludes the use of either drapes or shades.

Consider the following Window sub-block examples:

Example 1:

```
WINDOW
1 .9 .1
4 5
  3
1  0 8 2
1  0 18 2
1  0 28 2
BARRIERS
1. 1. -1. 1.5  .25
-1. 1. 1. 1.5  .25
1. 1. -1. 1.5  .25
0 0 0 0 0
SHELF
 0 1.0 0.75
BLINDS
 1 .02083  0.1667 0.1458  30 .80
```

This example defines 3 windows on the west wall. Each window opening is 4' across by 5' high; the windows span z-coordinates 2 - 7 and y-coordinates 8-12, 18-22, and 28-32. Barriers extend from each side and across the top of the exterior window opening. Each barrier has reflectance = 25% and protrudes 1.5 feet from the west wall. The side barriers are 1' on either side of the window opening and extend 1' below the window opening . The top barrier is 1' below the top window opening (this implies a sloping overhang which starts at the wall at or above the window opening). A light shelf protrudes 1' into the room from the bottom of the window opening; its reflectance is 75%. Venetian blinds are defined as follows:

```
thickness - 1/4 inch (= .02083 foot)
width     - 2 inches (= .1667 foot)
spacing   - 1.75 inches (= .1458 foot)
angle of opening - 30 degrees
reflectance - 80 %
```

Example 2:

```
WINDOW
 1 .9 .1
6. 5.
 2
4  7 0 3
4  19 0 3
DRAPE
 .60 0 2.5
```

This example defines 2 windows on the south wall; each has clear glazing of 90% transmittance and 10% reflectance. Dimensions are 6' across by 5' high. Each window runs from z-coordinate 3 to z-coordinate 8. The x-coordinates spanned on the south wall are 7-13 and 19-25. The westernmost 2.5' of each window is covered by a 60%-transmitting drape.

4.7.2 Clerestory sub-block

In the CEL-1 package a "clerestory" is defined as a rectangular protrusion from the room's ceiling. A clerestory structure has four vertical faces plus a top face. From one to all four of the vertical faces may transmit daylight; the top face may not transmit daylight (if the top transmits daylight, we have a skylight). A clerestory is defined by the following sequence:

```
CLERESTORY
<width>  <length>  <depth>  <glaze>
<transm. 1>  <transm. 2>  <transm. 3>  <transm. 4>  <transm. 5>
<# locations>
<x>  <y>  <z>
   .
   .              repeat for each location
   .

<x>  <y>  <z>
```

where

<width> is the east-west dimension of the clerestory structure (i.e., the width of the opening in the ceiling).

<length> is the north-south dimension of the clerestory structure (i.e., the length of the opening in the ceiling).

<depth> is the height of the clerestory structure (distance from ceiling to top of clerestory).

<glaze> is the integer value 1 or 2:
1 - glazing is clear
2 - glazing is diffusing

<transm. i> is the transmittance of the i'th face of the clerestory structure; the faces are numbered as follows:
face 1 - west face
face 2 - north face
face 3 - east face
facd 4 - south face
face 5 - top face
Each transmittance value may lie in the range (-1.1). A positive transmittance indicates that the face in question transmits daylight with the transmittance value given. A negative value means that the face does not transmit daylight; the absolute value of the negative transmittance is taken as the reflectance of the face. Note that the top face must always have a negative value. since it must be non-transmitting.

<# locations> is the number of clerestories in the ceiling which have the set of characteristics defined in the

previous lines

<x> <y> <z> gives the (x,y.z) location of the corner of each clerestory structure which is nearest to the origin. The z-coordinate will always be the ceiling height. One line of <x> <y> <z> values must be present for each separate clerestory location.

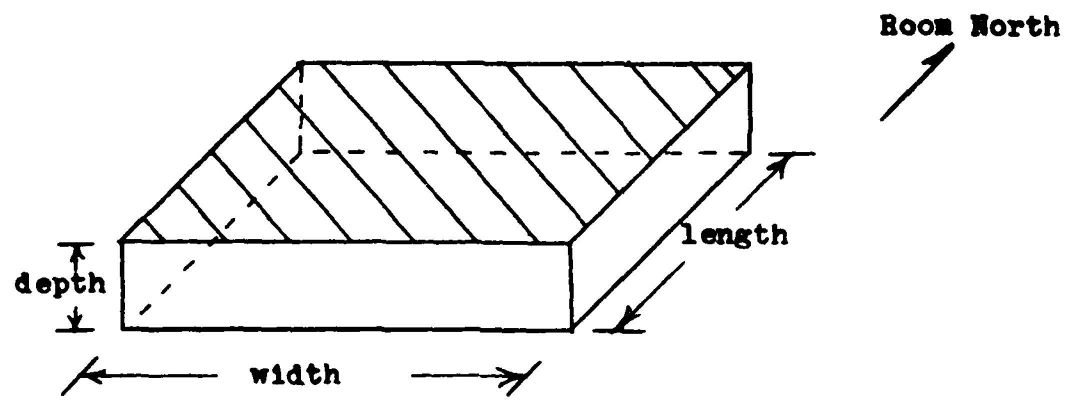


Figure 23: Clerestory structure. Top face may not transmit daylight.

Example:

```
CLERESTORY
 10 12 4  1
.91 .92 -.3 .94 -.6
 2
5 5 10
20 20 10
```

This example defines 2 clerestory structures on a 10' ceiling. Each structure is 10' wide (E-W), 12' long (N-S) and extends 4' above the ceiling. The first structure spans from x=5 to x=15 and from y=5 to y=17; the second spans from x=20 to x=30 and from y=20 to y=32. The west, north, and south faces transmit daylight with transmittance factors of 91%, 92%, and 94%, respectively. The east and top faces are non-transmitting and have reflectances 30% and 60%, respectively.

4.7.3 SAWTOOTH sub-block

A sawtooth monitor extends from a rectangular opening in the ceiling; it is made up of 4 surfaces (faces). One vertical face is rectangular and transmits daylight; the remaining two vertical faces are triangular and do not transmit daylight; the fourth face is a sloping rectangular face which likewise does not transmit daylight. A sawtooth monitor is defined as follows in the input file:

```
SAWTOOTH
<width>  <length>  <height>  <glaze>  <direction>
<transmittance>  <reflectance v>  <reflectance s>
<# locations>
<x>  <y>  <z>
   .
   .                        repeat for each location
   .

<x>  <y>  <z>
```

where

<width> is the width (E-W) of the sawtooth monitor (I.e., the width of the ceiling opening).

<length> is the length (N-S) of the sawtooth monitor (i.e., the length of the ceiling opening).

<height> is the height of the sawtooth monitor (i.e., the distance from the ceiling to the top of the monitor).

<glaze> = 1 if the vertical surface glazing is clear
= 2 if the vertical surface glazing is diffusing

<direction> is the direction faced by the vertical (transmittIng) surface. This is one of four integer values:
1 - west
2 - north
3 - east
4 - south

<transmittance> is the transmittance (range: 0-1) of the glazing on the vertical face of the sawtooth.

<reflectance v> is the reflectance (range: 0-1) of the triangular vertical faces of the sawtooth.

<reflectance s> is the reflectance (range: 0-1) of the sloping top surface of the sawtooth.

<# locations> is an integer giving the number of occurences of this sawtooth monitor in the ceiling.

<x> <y> <z> gives the (x,y,z) coordinates on the ceiling of the corner of the sawtooth which is nearest to the room origin. One such line must be present for each sawtooth location.

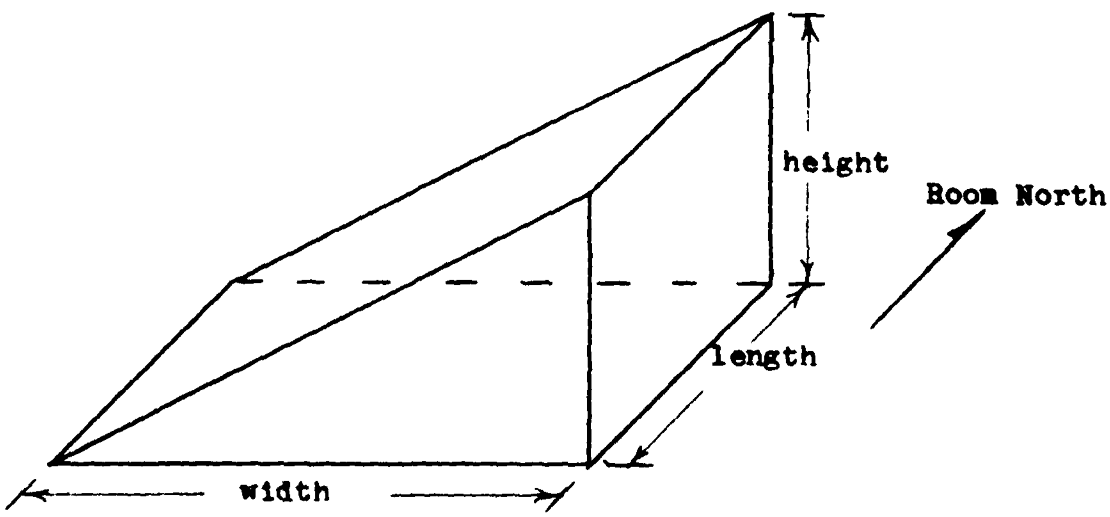


Figure 24: Sawtooth Monitor. Only the vertical rectangular surface transmits daylight. Note that the length, width input parameters bear the relationship shown to room north, regardless of which face the vertical transmitting surface lies on.

Example:

```
SAWTOOTH
 10 8 5  1 3
.93 .81 .82
  2
20 5 10
2 20 10
```

The vertical surface of this sawtooth is 93% transmitting, 5' high, and faces east (direction 3). The glazing is clear. The vertical triangular surfaces run east-west and have 82% reflectance. The sloping rectangular surface has 81% reflectance; it slopes from the ceiling on the west to 5' above the ceiling on the east. The first sawtooth opening in the ceiling runs from x=20 to x=30, and from y=5 to y=13. The second sawtooth opening runs from x=2 to x=12 and from y=20 to y=28.

Note that CEL-1 assumes that the entire vertical surface transmits daylight. If this is not the case, the user should enter a quasi-transmittance value which accounts for this fact. In the example above the transmitting vertical surface is 5' x 8'. If the glazing portion is only 4' x 7', then in obtaining the quasi-transmittance the use user should factor the actual transmittance by the proportion of the vertical surface which transmits daylight:

$$\text{quasi-transmittance} = (.93)\ (4 \times 7)\ /\ (5 \times 8) = 0.651$$

4.7.4 SKYLIGHT sub-block

In the CEL-1 package a "skylight" is defined as a rectangular opening in the ceiling which may or may not have a "well" extending above the ceiling. If a well is present, the top surface of the well must transmit daylight. If no well is present, then the ceiling opening must transmit daylight. Define a skylight as follows:

SKYLIGHT
<width> <length> <depth> <glaze>
<transm. 1> <transm. 2> <transm. 3> <transm. 4> <transm. 5>
<# locations>
<x> <y> <z>
.
. repeat for each location
.
<x> <y> <z>

where

<width> is the E-W dimension of the skylight structure (= width of the ceiling opening).

<length> is the N-S dimension of the skylight structure (= length of the ceiling opening).

<depth> is the height of the well wall. A zero entry means that there is no well (skylight is flush to ceiling).

<glaze> = 1 if glazing is clear
= 2 if glazing is diffusing

<transm. x> gives the transmittance of the x'th well wall or top surface of the skylight structure; the numbering is as follows:

1 - west well wall
2 - north well wall
3 - east well wall
4 - south well wall
5 - top of skylight

Each transmittance value may lie in the range (-1,1). A positive transmittance indicates that the face in question transmits daylight with the transmittance given. A negative value means that the face does not transmit daylight; the absolute value of the negative transmittance is taken as the reflectance of the face. Note that the top of the skylight must have a positive value, since it must transmit daylight. If no well walls are present (i.e., <depth> = 0), then the first four transmittance values entered should be zero.

<# locations> gives the number of skylights with the character-

istics defined above which appear in the ceiling.

<x> <y> <z> gives the (x,y.z) location of the corner of each ceiling opening which is nearest to the origin. One line of <x> <y> <z> values must be present for each separate skylight location.

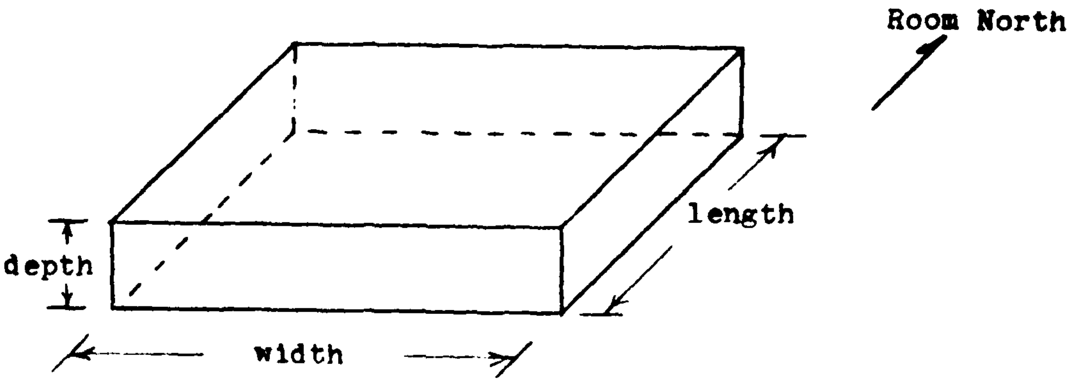


Figure 25: Skylight structure. Any or all of the five faces may transmit daylight.

Example:

```
SKYLIGHT
 6 8 2 1
-.8 .9 -.8 .9 .9
 1
10 30 10
```

This example defines one skylight which runs from x=10 to x=16 and from y=30 to y=38. The ceiling height is 10'. The skylight has a 2' high well; the west and east well walls are non-transmitting, with reflectance = 80%. The north and south well walls and the skylight top are 90% transmitting. All glazing is clear.

Note that CEL-1 assumes that if a surface transmits daylight, the entire area spanned by the surface transmits. If this is not the case, then the user should enter a quasi-transmittance for the surface in question -- this quasi-transmittance should take into account the actual transmittance of the surface, plus the ratio of surface area which transmits to the total area of the surface. For more detail, refer to the example given in the discussion of the SAWTOOTH sub-block.

4.7.5 BUILDING sub-block

This sub-block is used to define the locations of the object building and other buildings the user wishes to have an effect on the calculations. The "object" building is the building in which the room to be analyzed lies. Since its orientation with respect to true north is critical to daylighting calculations, the object building must always be defined -- thus, the BUILDING sub-block must always be included in the FENESTRATION block.

Buildings other than the object building may be specified at the user's option. To specify buildings go through the following process:

1) For each building designate each of the faces as one of the major compass directions: north face, south face, etc. These designations must be as close to reality as possible; e.g., the buildings "north" may actually face northeast, but it must not face southeast, etc. Note that the object building has the same orientation as the room; e.g., the room west wall and object building west face are parallel, etc.

2) After each face has been designated, determine the angular displacement from true north to the "west" face of each building. If step 1) was performed properly, the absolute value of this angle will be no greater than 45 .

3) Enter the values as follows in the input stream:

```
BUILDING
<# buildings>
<building size and location>   \
<reflectances>                  }   repeat for each building
<displacement angle>           /
```

where

<# buildings> is an integer giving the # of buildings specified in the lines below. This integer value must be at least one, since the object building must always be specified. For the upper limit, see the comments which follow the GROUND sub-block discussion.

<building size and location> consists of the following 6 values:

<x> <y> <z> <E-W dimension> <N-S dimension> <height>

where

<x> <y> <z> are the (x,y,z) coordinates of the southwest corner of the building at ground level. These and any other (x,y,z) coordinates are relative to the room origin.

<E-W dimension> is the width of the building, the distance from the east face to the west face.

<N-S dimension> is the length of the building, the distance from the south face to the north face.

<height> is the height of the building.

<reflectances> gives the reflectances of the five building faces:

<refl 1> <refl 2> <refl 3> <refl 4> <refl 5>

The faces are numbered as follows:
1 - west face
2 - north face
3 - east face
4 - south face
5 - roof

<displacement angle> gives the displacement (in degrees) of the west face of the building from true north. This value must not be less than -45° nor greater than +45° . A negative angle indicates a counter-clockwise displacement; a positive angle indicates a clockwise displacement.

Note that the 3 lines defining a building are repeated for each building to be specified. Consider the following example:

```
BUILDING
  2
-100 0 -35  250 250 45
 .6 .6 .6 .6 .2
-30
38 -1032 -35  100 300 80
 .5 .5 .5 .5 .5
15
```

The example defines two buildings:

1) The first building is 250' long, 250' wide. and 45' high. Each wall has reflectance 60%; the roof has reflectance 20%. The west wall angles 30° west of true north. The southwest corner of the building is located at (-100,0,-35). Since this first building is the object building, this implies that the room borders the south wall of the building, has no more than 10' ceiling height, and the floor is 35' above ground.

2) The second building is 100' wide (E-W), 300' long (N-S), and 80' high; each of its faces has reflectance = 50%. Its west wall angles 15° east of true north. Its southwest corner is located at (38,-1032,-35).

4.7.6 GROUND sub-block

This sub-block defines the reflectance of the ground and the extent and reflectance of any ground "inserts". A ground "insert" is any rectangular area on the ground which has reflectance differing from that of the ground as a whole. The boundaries of a ground insert must be parallel to the walls of the room. The reflectance of the ground as a whole is a required input for any daylight calculations; hence the GROUND sub-block must always be included in the FENESTRATION block. The format of the GROUND sub-block is:

```
GROUND
<ground reflectance>
<# inserts>
<insert refl.>  <xl>  <xr>  <yb>  <yt>  <z>    <--repeat for each
     .
     .
     .
<insert refl.>  <xl>  <xr>  <yb>  <yt>  <z>
```

where

<ground reflectance> is the reflectance (range: 0-1) of the ground as a whole.

<# inserts> is an integer value (zero or more) which gives the number of ground inserts to be defined. For the upper limit, see the discussion at the end of this section.

<insert refl.> is the reflectance of the ground insert (range: 0-1).

<xl> is the x-coordinate of the leftmost boundary of the insert.

<xr> is the x-coordinate of the rightmost boundary of the insert.

<yb> is the y-coordinate of the lower boundary of the insert.

<yt> is the y-coordinate of the upper boundary of the insert.

<z> is the z-coordinate of the insert.

Note that the line which defines an insert must be repeated once for each insert present. If zero inserts are specified, then no such lines should be included.

The following considerations apply to the BUILDING and GROUND sub-blocks:

1. A ray-tracing algorithm is used to determine the daylighting effects of buildings and ground. Rays from room fenestration are traced until they strike a building, the ground, or

a ground insert. Rays which strike none of these must strike the sky.

2. When a ray is traced, a list of exterior surfaces is scanned to see if the ray strikes any of them. This list of surfaces is constructed from the BUILDING and GROUND sub-blocks. Each building counts as 5 surfaces, each ground insert counts as one surface, and the ground as a whole counts as one surface.

3. If any barriers are defined for any windows, that counts as 4 surfaces for the ray-tracing. Four and only four surfaces are added for barriers, regardless of how many barrier definitions are present.

4. The maximum number of surfaces which may be defined is 30. The ground counts as one surface, so that at most 5 buildings may be defined (6 buildings would result in 31 surfaces). As an example, suppose that at least one barrier definition is present, and we have 3 ground inserts. The number of "free" surfaces is then

```
  30
 - 1   (ground)
 - 3   (ground inserts)
 - 4   (barriers)
-----
  22   "free" surfaces
```

   In this case we could specify at most 4 buildings.

5. Since the purpose of building and ground insert definitions is to define surfaces which may intercept light rays, the only requirements governing the building and ground insert definitions are:

   a) The starting z-coordinate of any building or ground insert must not be greater than zero (i.e., no building's lowest point nor any ground insert may be above the floor of the room).

   b) The object building must have both x and y starting coordinate less than or equal to zero (i.e., the room must lie entirely within the object building).

   c) If ceiling fenestration is present, the object building must be defined so that its roof and the room ceiling have the same z-coordinate.

4.8 FURNITURE block

This input block is used to define the locations of obstructions in the room; it is always optional in the input deck. The format of the block is:

```
FURNITURE
<# obstructions>
<ID>  <x>  <y>  <z>  <orientation>
    .                                   repeat for each
    .                                   obstruction
    .

<ID>  <x>  <y>  <z>  <orientation>
```

where

<# obstructions> is an integer giving the number of obstructions defined in the block. There must be at least one obstruction or the FURNITURE block must be omitted.

<ID> is the sequential position (integer value) of the obstruction in the OBSTR database. Refer to the section "Obstructions" for details on the OBSTR database.

<x> <y> <z> are the (x,y,z) coordinates of the exact center of the top face of the obstruction.

<orientation> is the angular displacement (Degrees) between room north and the west face of the obstruction (as the obstruction is defined in the OBSTR database). A positive angle indicates a clockwise displacement; a negative angle indicates a counter-clockwise displacement.

Consider the following example:

columns may be specified.

```
 3
1 21.5 34.75 6   0
9 8 25   5 90
4 23 18 4   -90
```

Three obstructions are defined:

1) The first obstruction defined in OBSTR is located with its top center at (21.5,34.75,6). Its orientation in the room is the same as its OBSTR orientation.

2) The ninth obstruction defined in OBSTR has its top center located at (8,25,5). In the room, the object has been rotated 90° clockwise (relative to its OBSTR definition).

3) The fourth obstruction defined in OBSTR has its top center located at (23,18,4). In the room, the object has been rotated

90° counter-clockwise (relative to its OBSTR orientation).

The following discussion will aid the user in determining how many objects he can place in the room:

CEL-1 handles room obstructions by breaking them up into planar surfaces and performing ray-tracing logic to determine when, for example, a particular target point might be shielded from a portion of a luminaire. Each obstruction specified in the FURNITURE block presents 5 planar surfaces to the ray-tracing logic (the bottom surface need not be considered, since it can never intercept light traveling toward a target point).

In addition to obstructions, the following also present surfaces to the ray-tracing logic:

a) Room walls, ceiling, and floor - total of 6 surfaces.

b) Inserts on walls, floor, or ceiling - 1 surface per insert.

c) Fenestration - 1 surface per fenestration source element (a fenestration source element is one window, skylight, clerestory structure, or sawtooth monitor).

A maximum of 75 surfaces may be presented to the ray-tracing logic. Suppose, then, that our room has 5 windows, 2 skylights, and 3 wall inserts. The number of "free" surfaces for ray-tracing logic is then:

```
 75
- 6   (room surfaces)
- 5   (windows)
- 2   (skylights)
- 3   (inserts)
-----
 59   "free" surfaces
```

Since each obstruction presents 5 surfaces, we may in this case locate eleven obstructions within the room.

4.9 PROFILE block

The PROFILE input block must be included in the input stream when using CEL-1 daylight capability in "profile" mode; it is not used at any other time. The form of the block is:

```
PROFILE
<latitude>  <longitude>  <time zone meridian>  <station ID>
<DST map>
<occupancy factors>
```

where

<latitude> is the latitude of the site under consideration. Latitudes are measured in degrees from the equator. Sites in the northern hemisphere have positive latitude; those in the southern hemisphere have negative latitude.

<longitude> is the longitude of the site. Longitude is measured in degrees from the Greenwich meridian. Sites in the western hemisphere have positive longitude; sites in the eastern hemisphere have negative longitude.

<time zone meridian> is the longitude of the meridian at the center of the time zone containing the site. For example, this value is 75° for the Eastern Time Zone, 90° for the Central Time Zone, etc.

<station ID> is an integer which identifies the weather station from which cloud conditions are to be determined. This integer gives the sequential position of the weather station in the CLOUDS disc file. For complete details refer to the section "Cloud Conditions".

<DST map> is a line of twelve integer values which indicate when Daylight Savings Time prevails. The first value on the line corresponds to January, the second corresponds to February, etc. A zero entry means that Daylight Savings Time is not in effect during the corresponding month. A 1 entry means DST is in effect during the corresponding month.

<occupancy factors> is a line of 24 real values which indicate, on an hourly basis, what proportion of the lighted space is occupied. The first of the 24 values corresponds to the time period 0000 - 0100; the second value corresponds to the period 0100 - 0200, etc. Each value must lie in the range 0 to 1; a 1 value means the space is 100% occupied; a zero value means the space is not occupied at all.

At each hour, the occupancy factor is multiplied by the watt-hours computed by the dimming algorithm. The result becomes part of the overall energy profile.

Example:

```
PROFILE
 42.4 83.1 75  21
0 0 0 0 1 1 1 1 1 1 0 0
0 0 0 0 0 0 0 0 1 1 1 1 0.5 1 1 1 1 0 0 0 0 0 0 0
```

Site latitude is 42.4 (north); longitude is 83.1 (west). The longitude at the center of the time zone is 75°. Cloud conditions are those prevailing for weather station # 21. Daylight Savings Time is to be in effect during the months May thru October. The room is unoccupied from 1700 each day til 0800 the following morning. Otherwise it is fully occupied, except from 1200 - 1300, when it is half-occupied.

4.10 ANALYSIS block

This input block must be included when using CEL-1 daylight capability in "analysis" mode; it is not used at any other time. The format of the block is:

```
ANALYSIS
<latitude>  <longitude>  <time zone meridian>  <station ID>
<DST map>
<# times>
<month>  <day>  <time>    }
   .                      }
   .                      }    repeat for each time
   .                      }
<month>  <day>  <time>    }
```

Refer to the "PROFILE block" section for a discussion of the inputs <latitude>. <longitude>. <time zone meridian>. <station ID>, and <DST map>. The remaining inputs are as follows:

<# times> is an integer value (range: 1-15) which gives the number of instants during the year for which the calculations are to be made.

<month> is an integer from 1 to 12 specifying the month.

<day> is an integer from 1 to 31 specifying the day of the month.

<time> is the time-of-day on a 24-hour clock. E.g., 1425 = 2:25 pm.

In "analysis" mode all luminaires are considered to be operating at full gain. except those explicitly specified as "off" in the DIMMING block. Consider the following example:

```
ANALYSIS
 42.4 83.1 75  21
0 0 0 0 1 1 1 1 1 1 0 0
 3
12 22 1400
3 21 1300
6 21 900
```

Calculations are to be made for three times during the year:
1) December 22, at 2 p.m.
2) March 21. at 1 p.m.
3) June 21. at 9 a.m.
Latitude is 42.4 (north), longitude is 83.1 (west). The meridian at the center of the time zone is at 75° longitude. Cloud conditions are those from weather station # 21. Daylight Savings Time is in effect from May thru October.

4.11 LUMINAIRES block

This block specifies the locations, orientations, etc. of the luminaires to be used. The block must be omitted when running the Design Synthesizer; it is optional in "analysis" mode of daylighting calculations; the block must be included in the deck in all other cases.

This is the only CEL-1 input block which may be repeated (up to a maximum of 5 blocks). One LUMINAIRES block corresponds to one particular photometric candela distribution. There must be one separate LUMINAIRES block for each different photometric distribution used on any one CEL-1 execution. The structure of the LUMINAIRES input block is as follows:

```
LUMINAIRES
<photo file name>
<lumens>  <light loss factor>
<width>  <length>  <height>  <watts>
<minimum gain>  <quadratic coefficients>
<# luminaires>
<sequence #>  <x-loc>  <y-loc>  <z-loc>  <bearing>  <tilt>  <cant>
    .
    .
    .
<sequence #>  <x-loc>  <y-loc>  <z-loc>  <bearing>  <tilt>  <cant>
```

where

<photo file name> is the name of the file containing the photometric data to be used for luminaires defined in this block. This name is from 1 to 7 alphanumeric characters and must begin in column 1.

<lumens> specifies the initial lamp lumens to be used in the calculations. If the luminaire has more than one lamp, then the sum of all the lamp lumens should be entered.

<light loss factor> gives the light loss factor accounting for any ballast, dirt depreciation, or lamp lumen depreciation. The range of this input is (0..1.)

<width> is the width of the luminaire. Width is measured along the 90 - 270 photometric planes.

<length> is the length of the luminaire. Length is measured along the 0 - 180 photometric planes.

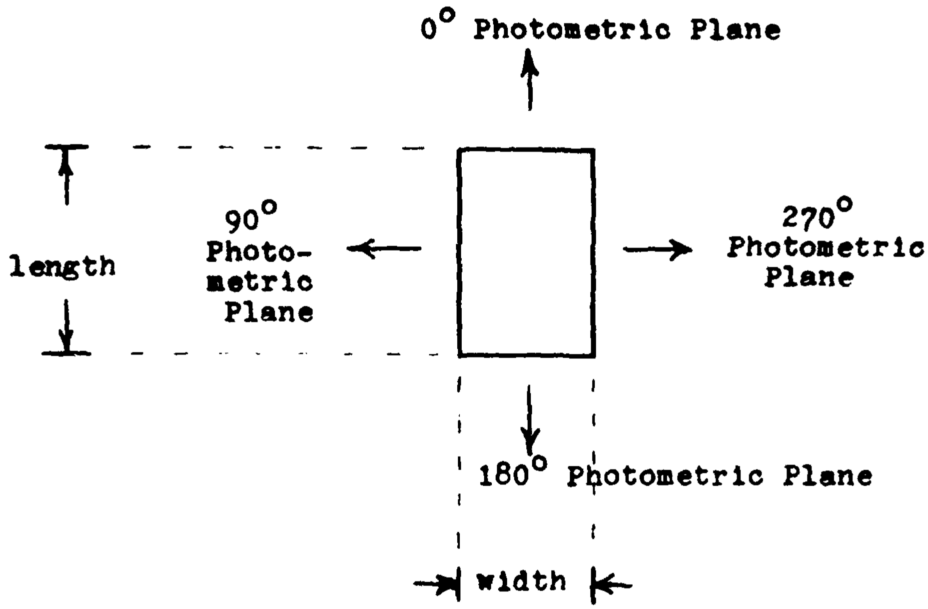


Figure 26: Top view of luminaire, illustrating definitions of length, width.

<height> is the height of the luminaire. This is the distance between the upper and lower luminous planes of the luminaire. A nonzero height is used only for luminaires which have light in both hemispheres.

NOTE: Care must be taken in entering the z-coordinate and the height of the luminaire. The program will assume that any downward light from the luminaire will originate at the z-coordinate given as the luminaire location. The program will assume that any upward light will originate at the z-coordinate plus the luminaire height. Hence the following strategy is recommended:

1. If the luminaire is downlight only. enter 0 as the luminaire height. and as the z-coordinate enter the distance from the floor to the luminous opening.

2. If the luminaire is uplight only. enter 0 as the luminaire height. and as the z-coordinate enter the distance from the floor to the luminous opening on top of the luminaire.

3. If the luminaire has both uplight and downlight. enter the actual height of the luminaire. As the z-coordinate

enter the distance from the floor to the luminous bottom of the luminaire.

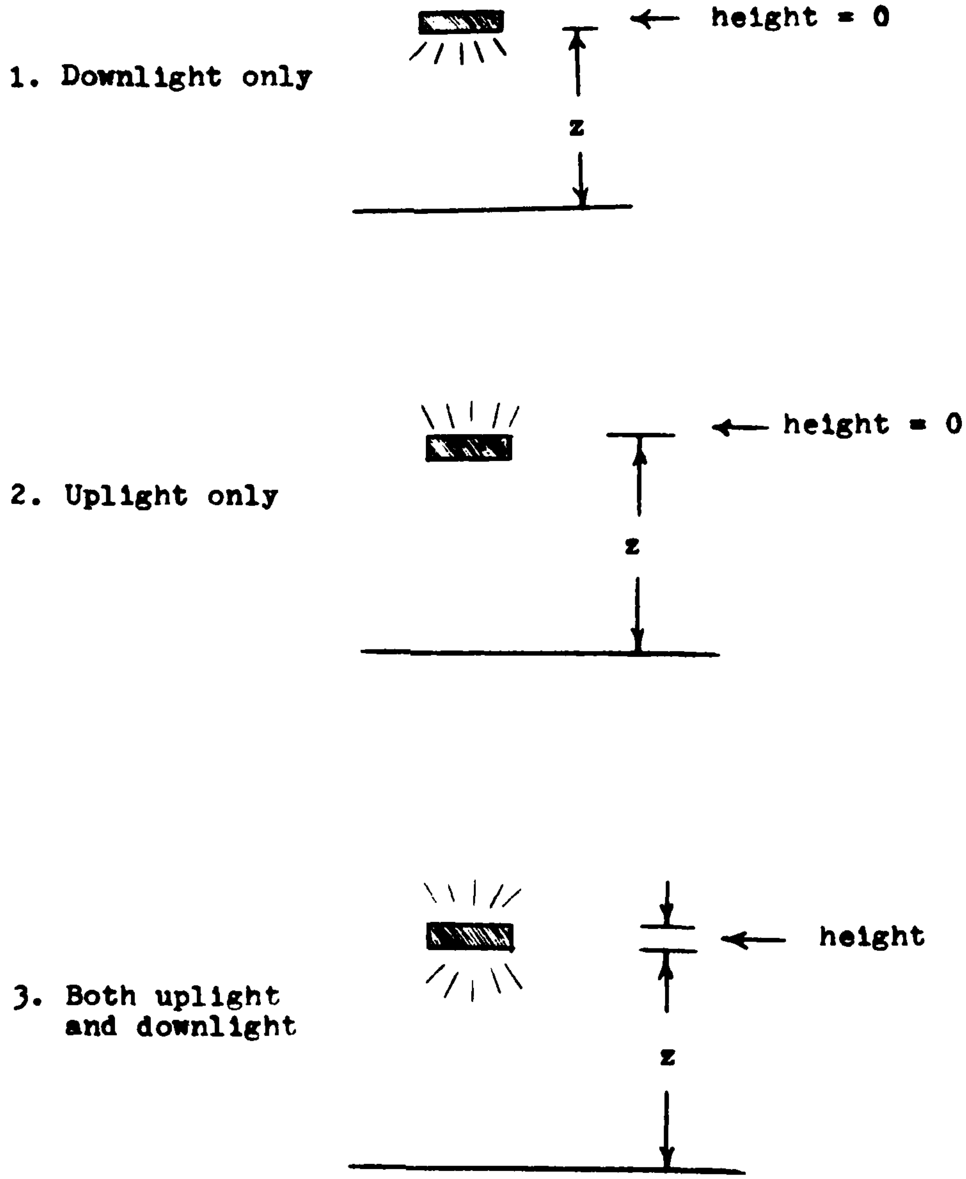


Figure 27: Definition of the luminaire 'height' parameter.

<watts> gives the watts consumed by the luminaire when all its lamps are turned on.

<minimum gain> is the minimum gain to which the luminaire can be lowered under continuous dimming control (0 gain = luminaire off; 1.0 gain (full) = luminaire on; light output is linear between zero and full gain).

<quadratic coefficients> are 3 coefficients A, B, C which relate watts consumed to gain (gain = % light output) as follows:

$$\text{watts} = A \times \text{gain}^2 + B \times \text{gain} + C$$

For example, if A = 2, B = 90, C = 3 and the gain setting is 0.5, then

$$\text{watts} = 2 \times 0.5^2 + 90 \times 0.5 + 3$$
$$= 48.5$$

<# luminaires> is an integer giving the number of luminaires whose locations are given in this block.

<sequence #> is an integer which uniquely identifies each luminaire located in the room. The first luminaire must be # 1, and the sequence # must be incremented by 1 each time another luminaire location is specified. Note that the sequencing continues across LUMINAIRES blocks, whenever more than one is present. E.g., the first LUMINAIRES block locates 9 luminaires (numbered 1 - 9); the second LUMINAIRES block locates 5 luminaires (numbered 10-14). A maximum of 100 luminaires may be specified (all LUMINAIRES blocks).

<x-loc> is the x-coordinate of the luminaire center.

<y-loc> is the y-coordinate of the luminaire center.

<z-loc> is the z-coordinate of the lower luminous surface of the luminaire.

<bearing> defines the angular separation of the 0 photometric plane of the luminaire from room north.

<tilt> defines the angular separation of photometric nadir from a vertical plumb line, when the luminaire is viewed normal to the 0 - 180 photometric plane.

<cant> defines the angular separation of photometric nadir from a vertical plumb line, when the luminaire is viewed normal to the 90 - 270 photometric plane.

Note that the inputs pertaining to watts and gain are used only by the energy profile algorithm. However, values must be entered in all cases (all zeroes may be entered since the program will only read the values from the card and will subsequently ignore them.

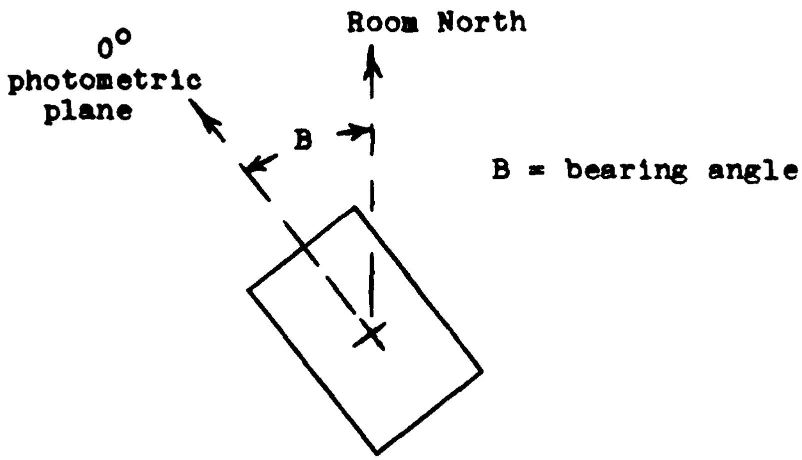


Figure 28: Definition of luminaire bearing angle. View is from above luminaire.

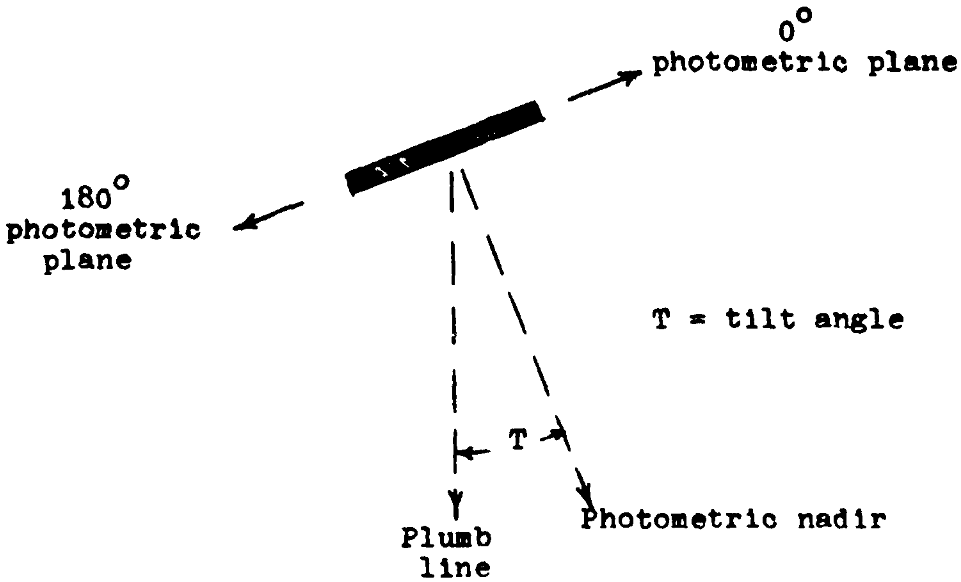


Figure 29: Side view of luminaire, illustrating the definition of the tilt angle. The tilt shown is a positive tilt. A tilt in the opposite direction is a negative tilt.

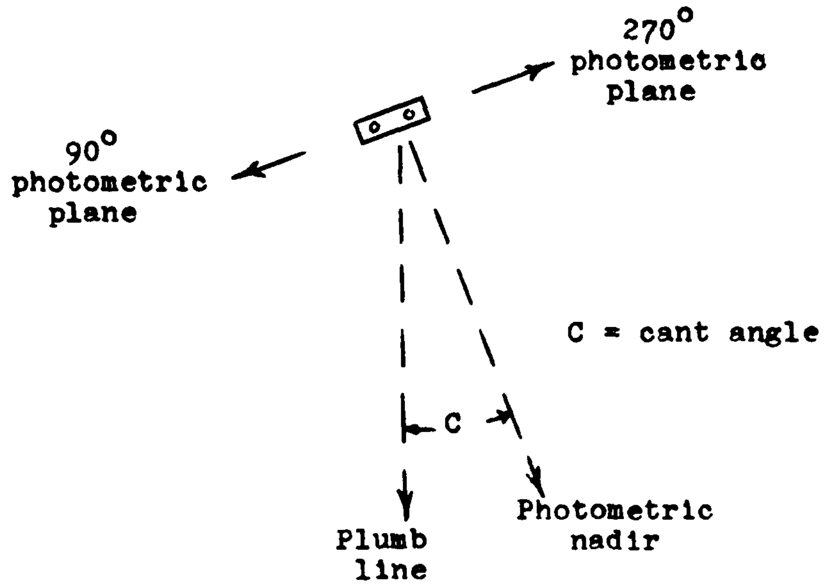


Figure 30: End view of luminaire, illustrating the definition of the cant angle. View is from "behind" the luminaire. The cant angle C shown is positive; a cant in the opposite direction is a negative cant.

4.12 DIMMING block

The DIMMING block is used only with CEL-1 daylight capability. It is optional in "analysis" mode and mandatory in "profile" mode. The format of the block is as follows:

<luminaire control method>
<luminaire control criterion value(s)>
<luminaire control indicator>
<control target area definition>
<# luminaires always off>
<list of up to 10 luminaires always off>
.
.
.
<list of up to 10 luminaires always off>
<# of luminaires in dimming group>
<list of up to 10 luminaires in the dimming group>
.
.
.
<list of up to 10 luminaires in the dimming group>

These input lines are defined as follows:

<luminaire control method> is one of the following integers:

1 - luminaires are to be controlled so that at a given time each luminaire is either "on" or "off".

2 - luminaires are to be controlled so that each is in one of three states:
"high" - full output
"low" - half output
"off" - zero output

3 - luminaires are to be controlled so that each controlled luminaire may be continuously dimmed from full output down to some user-specified minimum.

<luminaire control criterion value(s)> contains 1, 2, or 4 integer values depending on the <luminaire control method> selected in the preceding line:

control method	<luminaire control criterion values>
1	<val 1> <val 2> where

<val 1> and <val 2> are the illuminance values which define where luminaires are switched from "on" to "off" or vice-versa. When the luminaire control algorithm operates,

illuminance values are computed at the criterion points. (The controlling illuminance value may be either an average or a minimum.) Each luminaire (or group of two or more luminaires to be dimmed together) is then given a "new" setting based on its current setting and the controlling illuminance value V, as follows:

current setting	V < <val 1>	<val 1> ≤ V < <val 2>	<val 2> ≤ V
ON	ON	ON	OFF
OFF	ON	OFF	OFF

New Setting

For example, suppose <val 1> = 30 fc and <val 2> = 50 fc, and that the controlling illuminance value is the average illuminance over the user-specified target points. At each applicaiton of the dimming algorithm, a controlled luminaire will be set as follows:

ON if a) avg. illuminance < 30 fc
or b) 30 fc ≤ avg. illuminance < 50 fc
and the luminaire is currently ON.

OFF if a) 50 fc ≤ avg. illuminance
or b) 30 fc ≤ avg. illuminance < 50 fc
and the luminaire is currently OFF.

control method	<luminaire control criterion values>
2	<val 1> <val 2> <val 3> <val 4>

These inputs are in the same vein as those for control method 1 except that a luminaire may be in one of 3 states (high, low, or off) and there are 4 threshold values to determine when a luminaire is to change state. Again, the controlling illuminance value may be either an average or a minimum. The "new" setting of each luminaire (or group of luminaires dimmed together) is given in the following table:

current setting	Range of controlling illuminance: A	B	C	D	E
HIGH	HIGH	HIGH	LOW	LOW	OFF
LOW	HIGH	LOW	LOW	LOW	OFF
OFF	HIGH	LOW	LOW	OFF	OFF

New Settings

The ranges of controlling illuminance designations are:

A:			V	<	<val 1>
B:	<val 1>	≤	V	<	<val 2>
C:	<val 2>	≤	V	<	<val 3>
D:	<val 3>	≤	V	<	<val 4>
E:	<val 4>	≤	V		

control method	<luminaire control criterion value(s)>
3	<val 1>

In this case luminaires may be continuously dimmed, and <val 1> is the threshold value to be maintained when the dimming algorithm operates. <val 1> may be either an average or minimum illuminance value or it may be a minimum ESI value. Luminaires are dimmed to the maximum extent possible while maintaining the controlling illuminance value at no less than <val 1>.

<luminaire control indicators> This line contains exactly 5 integer values:

<i1> <i2> <i3> <i4> <i5>

One and only one of these must be 1 -- the remaining four must all be zero. Each value is associated with one controlling illuminance value. A value of 1 means that the associated controlling illuminance is to be used when the dimming algorithm executes. The associations are as follows:

<i1> Minimum illuminance over the user-defined target pts.

<i2> Average illuminance over the user-defined target pts.

<i3> Minimum illuminance over a "control target area".

<i4> Average illuminance over a "control target area".

<i5> Minimum ESI over the user-defined target points.

For example. the line

0 0 1 0 0

specifies that the user wishes the controlling illuminance value to be the minimum illuminance over a "control target area". Note that <i5> may be set to 1 only for the continuous dimming luminaire control method. <i1>

thru <i4> may be freely used with any of the three luminaire control methods.

<control target area definition> This line defines a set of points (in general, not the same as the target points) over which the control illuminance values are to be calculated. The format of the line is

<# columns> <# rows> <xl> <xr> <yb> <yt> <z>

where

<# columns> is the number of columns of points (integer value -- range: 0 thru 10)

<# rows> is the number of rows of points (integer value -- range: 0 thru 10)

<xl> is the x-coordinate of the leftmost column of points

<xr> is the x-coordinate of the rightmost column of points

<yb> is the y-coordinate of the bottom row of points

<yt> is the y-coordinate of the top row of points

<z> is the height of the points above the floor

For example, the line

5 4 10 30 5 20 2.5

defines a control target area 2.5 feet above the floor with 5 columns at x-coordinates 10, 15, 20, 25, and 30; and 4 rows at y-coordinates 5, 10, 15, and 20.

If the user does not wish to define a control target area, then all 7 values on the line should be zero. A control target area must be defined if and only if the <luminaire control indicators> line calls for minimum or average illuminance over a control target area (i.e., either <i3> or <i4> is set to 1).

<# luminaires always off> is one integer value which tells how many luminaires are to be always off during the calculations. This line is followed by one or more lines:

<list of up to 10 luminaires always off> There will be zero or more of these lines; each contains from one to ten integer values, each of which designates a luminaire to be always off. If more than one line is necessary, then only the last line may contain fewer than 10 values. If no luminaires are to be forced always off, then no lines designating luminaires will be present. For example, the four lines:

22

1 3 5 7 9 11 13 15 17 19
21 23 25 27 29 31 33 35 37 39
41 43

specify that all odd-numbered luminaires from 1 through 43 are to be "off" for the CEL-1 calculations.

<# of luminaires in the dimming group>

<list of up to 10 luminaires in the dimming group>

.
.
.

<list of up to 10 luminaires in the dimming group>

The construction of these lines is the same as that for the lines designating luminaires which are always off -- exactly 10 luminaires are designated on each line but the last, which contains only sufficient values to complete the group. For example, consider these lines:

16
1 4 5 6 7 8 9 10 11 12
19 20 21 22 23 24

The following luminaires are to be controlled:
1, 4, 5, 6, 7, 8, 9, 10, 11, 12
19, 20, 21, 22, 23, 24

4.13 DESIGN block

The DESIGN input block specifies input values to be used by the design synthesizer program. The form of the block is:

```
DESIGN
<photo file name>
<lumens>  <light loss factor>
<width>  <length>  <height>
<bearing>  <tilt>  <cant>
<minimum illum.>  <minimum ESI>  <average illum.>
<# columns>  <# rows>  <xl>  <xr>  <yb>  <yt>  <z>
<mask>
```

All numeric values down through <bearing> <tilt> <cant> are to those of the same function which are defined in the LUMINAIRES identical to those which are defined in the LUMINAIRES block. Refer to the discussion of the LUMINAIRES block for detailed descriptions of these parameters. The remaining cards are:

<minimum illum.> is the minumum illuminance design criterion value. I.e., the darkest point among the target points is to have at least this much illuminance. If zero is specified, then no minimum illuminance criterion will be used by the design synthesizer algorithm.

<minimum ESI> is the minimum ESI design criterion value. No target point is to have less ESI than this value. Zero may be specified, in which case no ESI criterion will be used.

<average illum.> is the average illuminance design criterion to be maintained over the target points. Zero is a permissible entry.

<# columns> is the number of columns of luminaires

<# rows> is the number of rows of luminaires

<xl> is the x-coordinate of the leftmost column of luminaires

<xr> is the x-coordinate of the rightmost column of luminaires

<yb> is the y-coordinate of the bottom row of luminaires

<yt> is the y-coordinate of the top row of luminaires

<z> is the z-coordinate of the plane containing the luminaires

<mask> The mask is an array of binary values (each value is either zero or one). The mask permits the user to modify

the rectangular grid by eliminating one or more luminaires from the rectangular pattern. To accomplish, one mask card is included for each row in the rectangular grid. Each mask card contains a number of binary values which is equal to the number of columns in the grid. A zero value means that the corresponding luminaire is to be omitted from the rectangular grid.

For example, suppose we have defined a rectangular grid with 3 rows of 4 luminaires each. The mask cards

```
1 1 1 1
1 0 0 1
1 1 1 1
```

would eliminate the two interior luminaires from the grid.

Note that the set of luminaires from which the synthesizer can pick the optimum subset is a rectangular grid with perhaps one or more luminaires omitted via the <mask> cards. The luminaires selected will be the smallest subset which meets the user's design criteria. The maximum allowed size of the user-defined set of possible luminaire locations is 100 luminaires. Within this limit, however, any number of rows may be defined and any number of columns not exceeding 40 may be defined. The rectangular grid may contain more than 100 luminaires, provided enough luminaires are eliminated with the <mask> cards to bring the total down to 100 or fewer. Note that even if the user does not wish to "mask out" any luminaires from the rectangular grid, the <mask> cards must be included in the data deck; in this case they would contain only 1's.

At least one of the three criterion values <minimum illum.>, <minimum ESI>, or <average illum.> must be non-zero; any two or all three may also be given as non-zero.

4.14 CALCULATE block

This input block tells CEL-1 which lighting metrics to calculate. The block takes the following format

```
CALCULATE
<keywords>
<background BRDF file name>
<task BRDF file name>
```

where

<keywords> is a list of 3-character keywords which tell what metrics are to be printed on the output report. The keywords are as follows:

HOR - print horizontal fc (no body shadow)

ESI - print Equivalent Sphere Illuminance (ESI)

RFC - print horizontal fc (incl. body shadow)

TAR - print target luminance

BAC - print background luminance

LEF - print Lighting Effectiveness Factor (LEF)

CRF - print Contrast Rendering Factor (CRF)

VCP - print Visual Comfort Probability (VCP)

PLH - print character contour plots of horizontal fc (no body shadow)

PLE - print character contour plots of ESI, in each viewing direction

PLV - print character contour plots of VCP, in each viewing direction

SUN - print a sketch of the room showing those portions of the task plane which are exposed to direct sunlight at any time during the year. This keyword is used only when the CEL-1 daylight capabilities are exercised.

TDY - print outputs which assist the user in executing the BLAST thermodynamics analysis program. For more details on this output, refer to Appendix C.

The keywords may appear on the line in any order; each pair must be separated by exactly one space. The first keyword must begin in column 1.

<background BRDF file name> is the name of the disc file containing the background luminance factors for the visual task in question. The file name is 1-7 characters and must begin in column 1.

<task BRDF file name> is the name of the disc file containing the task luminance factors for the visual task in question. The file name is 1-7 characters and must beginin column 1.

Note that the file names are required in this block only if the <keywords> line specifies a metric which requires BRDF data. The only keywords which do not require BRDF data are HOR, VCP, PLH, PLV, SUN, and TDY.

Example:
```
CALCULATE
HOR ESI VCP LEF PLE
P25B
P25T
```

Horizontal fc (no body shadow), Equivalent Sphere Illuminance, Visual Comfort Probability, and Lighting Effectiveness Factors are calculated. In addition, character contour plots of ESI are generated. Background luminance factors are in the file 'P25B'; task luminance factors are in file 'P25T'.

Note that character contour plots are available only for unknown task locations (TASK=UNKNOWN). The SUN keyword requires the presence of a FENESTRATION block definition.

SECTION V

Auxiliary Files

5.1 Types of Auxiliary Files

The following auxiliary files must exist on disc storage in order to execute CEL-1:

1) Obstruction database file
2) Cloudiness database file
3) Photometric files
4) BRDF files
5) IES Body Shadow file
6) RCS Curve file

In general. these files need only exist in the master CYBERNET account (S4696GS - CEL, Port Hueneme). However. it is possible to create and save files 1) and 3) in any other account and have them used as input to CEL-1. When the program needs to access one of files 1) or 3), it first searches the catalog of the user's own files. If the file exists in that catalog it is used as input and no further searching takes place. If the file does not exist in the user's own catalog, then the file is read from the master account's catalog. Note that files 2), 4), 5), and 6) must always be read from the master account. The six file types are described in the remainder of this section.

The first two file types listed above. the obstruction and cloudiness database files, are binary files. This means that they can be accessed only via a user program. The CEL-1 package includes programs which may be used to maintain these files; these programs are described below as well.

5.2 Obstructions

The CEL-1 package permits obstructions (furniture, partitions, file cabinets, etc.) to be present in the room. Obstructions should be thought of as rectangular solids and must be oriented so that each of the 6 faces of the obstruction is parallel to 2 of the room surfaces -- i.e., obstructions may not be tilted or skewed with respect to the room surfaces.

The dimensions and reflectances of obstructions are stored in the binary disc file OBSTR. The user maintains this file by executing the auxiliary program OBMP. In this fashion, the CEL-1 user need only specify the location and orientation of each obstruction at the time he executes a CEL-1 program. The dimensions and reflectances of the object will have been specified when the object was originally installed in the OBSTR database file.

To define an obstruction, position the obstruction so that its vertical surfaces are parallel to the major compass directions. The following inputs must then be specified when running OBMP:

a) N-S dimension (distance between north and south faces)

b) E-W dimension (distance between east and west faces)

c) Height (distance between top and bottom faces)

d) Six reflectance values, one for each face of the obstruction (Face 1 = west face, Face 2 = north face, Face 3 = east face, Face 4 = south face, Face 5 = bottom face, Face 6 = top face)

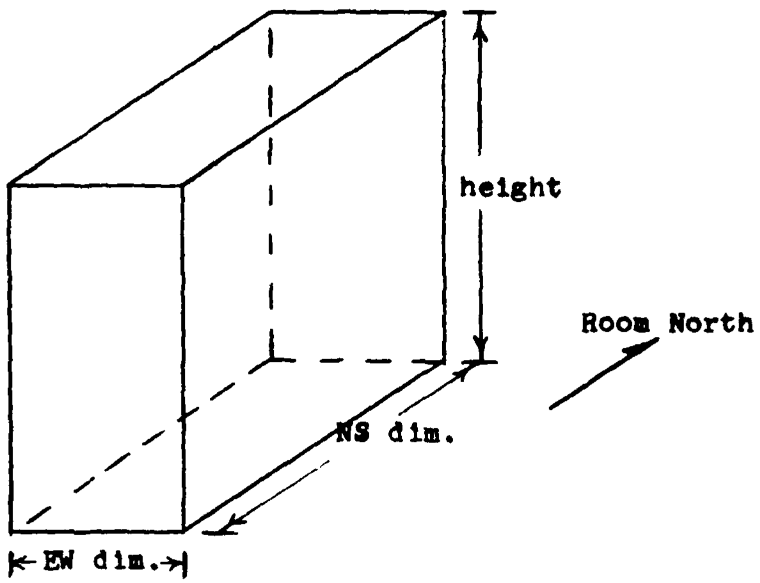


Figure 31: Defining obstructions as 6-sided rectangular objects.

Note that the numbering convention for the 6 faces of the obstruction coincides with that for numbering the room surfaces themselves.

In order to position an obstruction in the room, the CEL-1 user specifies these 3 parameters:

a) the numerical ID of the obstruction in the OBSTR database.

b) the (x,y,z) coordinates in the room of the center of the top surface (face) of the obstruction.

c) the orientation angle of the obstruction.

The numerical ID is simply the sequential position (first, second, third, etc.) of the object in the OBSTR database, and may be determined from a current listing of the OBSTR contents (generated by running OBMP). Four possible orientation angles are permitted to position an object in the room: 0, 90, 180, and -90 degrees. These rotate the obstruction relative to its OBSTR database definition. The following table gives the direction faced by each of the obstructions's 6 faces under the four possible orientations:

	Orientation Angle 0	90	180	-90
1. West face	W wall	N wall	E wall	S wall
2. North face	N wall	E wall	S wall	W wall
3. East face	E wall	S wall	W wall	N wall
4. South face	S wall	W wall	N wall	E wall
5. Bot. face	Floor	Floor	Floor	Floor
6. Top face	Ceiling	Ceiling	Ceiling	Ceiling

The above table entries give the room surface faced by each of the six obstruction faces. according to the obstruction orientation angle specified. Note that the actual orientation may be determined by positioning the object as it is defined in the database. then rotating it by the orientation angle. A positive angle calls for a clockwise rotation, and a negative angle calls for a counter-clockwise rotation.

5.2.1 Input Data Deck for the Auxiliary Program OBMP

OBMP is used to create and maintain the binary file OBSTR which contains the reflectances and dimensions of the obstructions which are defined for use with CEL-1. Four functions may be performed by OBMP:

1) Create a new OBSTR database. (if a OBSTR file already contains entries, this has the effect of deleting them all)

2) Add an obstruction definition.

3) Delete an obstruction definition.

4) Print the existing database contents.

Any or all of these functions may be specified, in any order, on a single OBMP execution. Note that when the database contents are listed, the obstructions will be numbered sequentially on the printout. The number corresponding to each obstruction is the numerical ID which the user codes in the CEL-1 input stream to identify which obstruction he wants to position in the room.

The data deck for running OBMP consists of one one or more entries (of one or two cards each) of the following form:

<keyword> (first card)
<parameters> (second card)

where <keyword> is:

CREATE delete any existing database entries and initialize the database for subsequent additions. In this case, no

<parameters> card is present.

ADD add an obstruction definition to the database. In this case the <parameters> card contains the following values:

<units> <NS dim.> <EW dim.> <height>
<refl 1> <refl 2> <refl 3> <refl 4> <refl 5> <refl 6>

where
<units> = 1 if dimensions are in feet
= 2 if dimensions are in meters

<NS dim.> is the North-South dimension of the obstruction (distance between north and south faces)

<EW dim.> is the east-west dimension of the obstruction (distance between east and west faces)

<height> is the height of the obstruction (distance between top and bottom faces)

<refl 1> is the reflectance of the west face of the obstruction

<refl 2> is the reflectance of the north face of the obstruction

etc.

The new obstruction definition will be entered after the last existing entry in OBSTR.

DELETE delete an obstruction definition from OBSTR. In this case the <parameters> card will contain one integer value -- the numerical ID (i.e., sequential position in OBSTR) of the obstruction to be deleted.

PRINT causes a printed listing of the current OBSTR database contents. No <parameters> card is used.

STOP halts execution of OBMP. This must be the last card in the input data stream.

The following errors may occur:
a) Misspelled keyword.
b) Zero or negative dimensions on object to be ADDed to OBSTR
c) Reflectance value outside the range [0.1] on an object to be ADDed.
d) Units specifier not 1 or 2.
e) Attempt to delete a non-existent entry.
f) No STOP card.

Any of these errors will cause OBMP to terminate, leaving the OBSTR file unchanged (even if correct entries are encountered before the error is detected). A diagnostic message will be printed informing the user of the error; the remainder of the input data deck will not be checked.

Suppose we want to delete the existing second entry of OBSTR, then add the following 3 objects to OBSTR:

1) File cabinet 5' high, 21" deep, 15" across; reflectance = 15% everywhere.

2) Desk 2.5' high, 5' wide, 3' deep. Reflectance of top = 45%; reflectance elsewhere = 20%.

3) Partition section 6' high, 8' across, 4" thick. Reflectance = 35%.

Here is what the data deck should look like to perform these functions, then list the database contents:

```
DELETE
 2
ADD
 1  1.75 1.25 5  .15 .15 .15 .15 .15 .15
ADD
 1  5.0 3.0 2.5  .2 .2 .2 .2 .2 .45
ADD
 1  8 0.33 6  .35 .35 .35 .35 .35 .35
PRINT
STOP
```

Note that all keyword entries must begin in column 1. Numeric data values are free-format -- i.e., no specific column alignment is required. Consecutive numeric data items must be separated by a comma and/or one or more spaces. Section V shows the complete job deck (including NOS control cards) for running OBMP.

5.3 Cloud Conditions

The energy profile algorithm. in order to compute expected energy consumption, must know how many days of each month are expected to be clear. partly cloudy. and overcast. These data will vary from weather station to weather station and from month to month. When CEL1D is executed, the required cloud condition information is obtained from the binary disc file CLOUDS.

For each weather station included, the CLOUDS file contains the following information:

a) text ID of the weather station
b) # clear days each month
c) # partly cloudy days each month
d) # overcast days each month

The user may update the contents of the CLOUDS file by executing the program CCMP.

5.3.1 Input Data Deck for the Auxiliary Program CCMP

CCMP is used to maintain the contents of the CLOUDS disc file; with it the user can perform the following functions:

1) Create a new CLOUDS file (if the CLOUDS file already contains bona fide entries, this function deletes them all).

2) Add a new weather station to the file.

3) Delete an existing weather station entry from the file.

4) Print the existing contents of the file.

To use CCMP the user prepares a data deck invoking one or more of these functions. Each function is invoked by a keyword card, followed by zero or more parameters cards:

```
<keyword>
<parameters>
    .
    .
    .
<parameters>
```

Details on the <keyword> entries are:

CREATE - Creates a new (initially empty) CLOUDS file. No <parameters> cards are used.

ADD - Adds an entry to the CLOUDS file. The new entry will be appended to the existing contents of the file. Four <parameters> cards follow the ADD keyword:

1) The first <parameters> card contains the text ID of the weather station being added. This ID will be the first 50 characters on the card.

2) The second <parameters> card contains twelve integer values, which give the number of overcast days each month. The first integer is the number of overcast days in January; the last is the number of overcast days in December, etc.

3) The third <parameters> card is similar to the second, except it gives the number of clear days in each month.

4) The fourth <parameters> card is similar to the second, except it gives the number of partly cloudy days in each month.

PRINT - Lists the contents of the CLOUDS file. No <parameters> cards are used. It is recommended that PRINT always be invoked when running CCMP; this is especially true when DELETE is used, since the resultant renumbering of the weather station entries will change the sequential position of a portion of the existing entries.

STOP - Halts execution of CCMP. This must be the last input card in the data deck.

For example, suppose we wish to delete stations 23 and 59, add a new station, then print the database contents. Here is what the input data deck would look like:

```
DELETE
 23
DELETE
59
ADD
EAST FLAT ROCK, NC
 12 10 11 13 14 12 11 11 10 8 9 11
 9 10 9 7 8 10 12 11 10 12 9 8
10 8 11 10 9 8 8 9 10 11 12 12
PRINT
STOP
```

Note that the alphabetic keywords must begin in column 1; numeric entries, however, are free-format (no specific column alignment is required). Consecutive numeric data values must be separated by a comma and/or one or more spaces. Section V shows a complete job stream (including NOS control statements) for executing CCMP.

5.4 Photometric Data Files

Each set of photometric candlepower data which is input to the program must be contained in a uniquely-named file. As with numeric values in the data deck itself, considerations are:

1. Numerical values may appear in free-format -- no specific column alignment is required.
2. 'Integer' values must be coded without a decimal point. 'Real' values may be coded either with or without a decimal point.

The line-by-line format of a photometric dataset is:

<text Id line 1>

<text ID line 2>

<lumens> <scale constant> <# rows> <# columns>

<lateral angles>

<vertical angle> <candela for this vertical angle>

<vertical angle> <candela for this vertical angle>

.
.
.

<vertical angle> <candela for this vertical angle>

Detailed explanations of these items are as follows:

<text ID line 1>
<text ID line 2>

The first two lines of the file may contain any descriptive text desired (maximum 80 characters per line). Suggested contents are the catalog number. lamp. photometric laboratory and report number. plus any other information pertinent to the luminaire.

<lumens> gives the lamp lumens used in the generation of the photometric report.

<scale constant> is a number used to multiply the candlepower values given. Usually it is 1; occasionally it might be desirable to divide all the candlepower values by 10 in order to have the photometric data file take up less disk space. In such a case the scale constant would be set to 10.

<# rows> gives the number of rows (= number of vertical angles) in the candlepower table.

<# columns> gives the number of columns (= number of lateral angles in the candlepower table.

<lateral angles> gives the list of lateral angles in the candle power table. Four different options exist for the range of the lateral angles, depending upon the symmetry present in the data:

a) Completely symmetric unit.

In this case all planes of data are identical, and only one plane (and one lateral angle) need be entered. The lateral angle should be given as zero.

b) Symmetric in all four quadrants.

In this case only the first quadrant need be given. The first plane (lateral angle) must be 0 degrees; the last must be 90 degrees.

c) Symmetric about the 0° - 180° plane.

In this case the first lateral angle must be 0° ; the last must be 180°.

d) Completely asymmetric.

The first lateral angle must be 0°; the last must be 360°, and all intervening lateral angles must be given. Note that the candela values in the 360° plane sill be identical to those in the 0° plane. They must be given in both places, however.

In all cases, the minimum separation between lateral angles must be 22.5 degrees. I.e., if the photometric data is expanded into all 4 quadrants, a maximum of 17 lateral angles is allowed.

<vertical angle> is the vertical angle to be followed by a list of the candlepower at that vertical angle. The first vertical angle in the dataset will be the highest vertical angle from the printed photometric report (usually 90° or 180°). The last vertical angle in the file must always be 0° vertical (nadir).

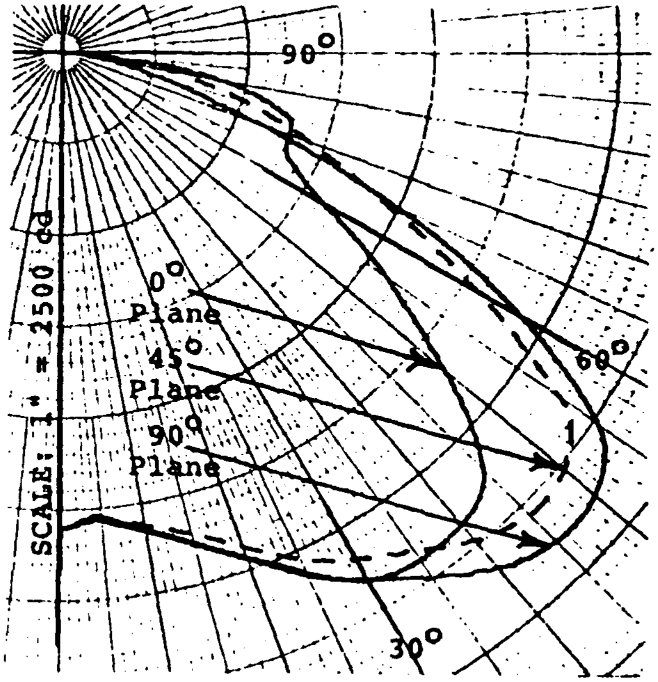
<candela for this vertical angle> is the list of the candela values for the vertical angle which is teh first number on the current line in the file. The candela should be listed in the same order as the list of lateral angles; each candela value corresponds to the lateral angle in the same position in the list.

Note that of the numeric values in the file, only <# rows> and

<# columns> are 'integer' values; all other data items required are 'real' values.

LAMPS One 400 watt High Pressure Sodium, rated 50000 lumens.
MOUNTING Pendant

CANDLEPOWER DEG	PARL	22.5	45	67.5	NORM	ZONAL FLUX
0	6497	6497	6497	6497	6497	
5	6358	6378	6398	6404	6422	607
15	6915	6861	6789	6892	6942	1944
25	7814	7780	7616	7805	7863	3593
35	8441	8384	8287	8679	8714	5327
45	8049	8367	8908	9276	9424	6828
55	5402	5889	8249	8705	8876	6723
65	3375	3604	4848	4894	5101	4365
75	3118	3217	2637	1600	1606	2596
85	787	834	756	368	381	693

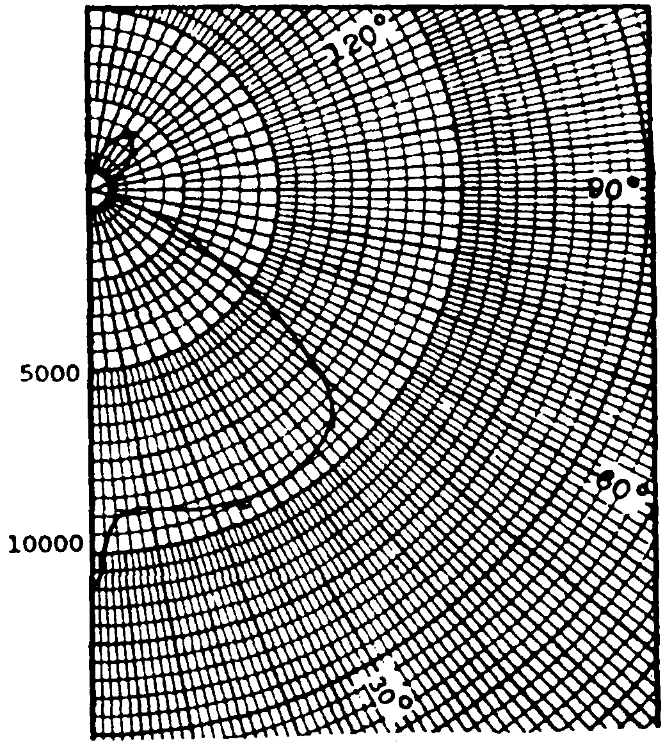



```
SAMPLE PHOTOMETRIC DATA FOR UNIT SYMMETRIC IN EACH QUADRANT
CAT. NO. ABCV, 400W HPS LAMP, RATED 50000 LUMENS.
 50000 1.0  11 5
   0 22.5 45 67.5 90
90 0 0 0 0 0
85 787 834 756 368 381
75 3118 3217 2637 1600 1606
65 3375 3604 4848 4894 5101
55 5402 5889 8249 8705 8876
45 8049 8367 8908 9276 9424
35 8441 8384 8287 8679 8714
25 7814 7780 7616 7805 7863
15 6915 6861 6789 6892 6942
5 6358 6378 6398 6404 6422
0 6497 6497 6497 6497 6497
```

Figure 32: Photometric file for luminaire symmetric in each quadrant.

LAMPS	One LU400, rated 50,000 lumens.
MOUNTING	Pendant

DEG	*CANDLEPOWER CP	ZONAL FLUX
0	10943	0
5	8832	839
15	9096	2574
25	9506	4401
35	9471	5948
45	9103	7046
55	5692	5106
65	2462	2445
75	1177	1245
85	267	291
90	38	0
95	104	114
105	298	315
115	418	415
125	778	698
135	1568	1213
145	1951	1225
155	1386	641
165	27	7
175	7	0
180	0	0




```
SAMPLE PHOTOMETRIC DATASET FOR COMPLETELY SYMMETRIC UNIT
CAT NO. $%^&@, 400WHPS LAMP, 50000 LUMENS
 50000 1.0  21 1
    0.
180      0
175      0
165     27
155   1386
145   1951
135   1568
125    778
115    418
105    298
 95    104
 90     38
 85    267
 75   1177
 65   2462
 55   5692
 45   9103
 35   9471
 25   9506
 15   9096
  5   8832
  0  10943
```

Figure 33: *Photometric file for completely symmetric luminaire.*

5.5 BRDF Files

The BRDF (Bi-directional Reflectance Distribution Function) files contain the laboratory-gathered numeric factors which enable CEL-1 to calculate task and background luminance at each target point. ESI follows from these quantities.

A single CEL-1 execution where ESI is to be calculated requires two BRDF files -- one apiece for background and task luminance factors. BRDF factors are used to "weight" light rays incident upon the target as to their effectiveness in producing task/background luminance. These weights are a function of the azimuth and declination angles of the incident ray.

If we have an observer looking due north, then the declination angle is the angle between zenith and the incident ray. The azimuth angle is the angle between due north and the projection of the incident ray onto the horizontal plane. The factors exhibit symmetry about the vertical N-S plane. Hence it is only necessary to know the factors in a 180-degree azimuth range. We shall call due north 0 degrees and call due south 180 degrees in designating azimuth angles. For the declination angles, zenith is 0 degrees; declination angles proceed upward to 90 as the angle displacement from zenith increases; 90 degrees is the horizontal plane at target level. BRDF factors are sampled every 5 degrees in each direction. If we then display the factors as a two dimensional table, with each row being one azimuthal plane and each column being a constant declination angle, we obtain a table with 37 rows and 19 columns.

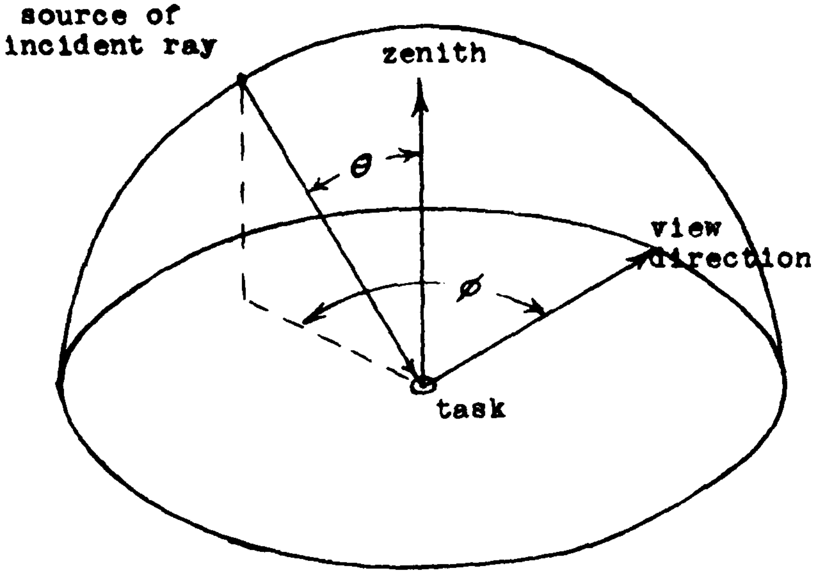


Figure 34 : Illustrating determination of azimuth and declination angles for BRDF calculation. ϕ = azimuth, θ = declination

A BRDF task luminance file is identical in format to a BRDF background luminance file. Each file consists of 74 card images. Beginning with the first pair of cards, each card pair corresponds to one azimuthal plane of factors. The first card pair is 0 degrees azimuth (due north); the second pair is 5 degrees, etc. The last pair is 180 deg. (due south). Each card pair contains 19 values -- 10 on the first card, 9 on the second. These 19 values are positioned so that they may be read with a FORTRAN FORMAT(10F7.0/7X,9F7.0). The first value is 0 deg. (zenith); the second value is 5 deg. declination, etc. The last value (always zero) is 90 degrees declination.

The following BRDF files are stored for use with CEL-1. In each case the first file name for each task is the file which contains the background luminance factors; the second file contains the task luminance factors.

Filename	Task
P10B P10T	Pencil target at 10 degree viewing angle
P25B P25T	Pencil target at 25 degree viewing angle
P325B P325T	Pencil target at 32.5 degree viewing angle
P40B P40T	Pencil target at 40 degree viewing angle
P55B P55T	Pencil target at 55 degree viewing angle
B25B B25T	Ballpoint pen target at 25 degree viewing angle
X25B X25T	Xerograph target at 25 degree viewing angle
O25B O25T	Offset printing target at 25 degree viewing angle
F25B F25T	Felt-tip pen target at 25 degree viewing angle
D10B D10T	Drafting task at 10 degree viewing angle

column 1
column 2

Figure 35: BRDF file (this one is P25B).

0.8460	0.8679	0.8956	0.9303	0.9722	1.0088	1.0245	1.0238	1.0161	1.0086
	1.0006	0.9942	0.9996	0.9923	0.9876	0.9786	0.9677	0.9557	0.0000
0.8460	0.8676	0.8963	0.9300	0.9696	1.0074	1.0220	1.0236	1.0116	1.0086
	0.9998	0.9968	0.9966	0.9888	0.9854	0.9758	0.9663	0.9557	0.0000
0.8465	0.8684	0.8963	0.9293	0.9681	1.0038	1.0172	1.0186	1.0104	1.0055
	0.9968	0.9930	0.9942	0.9878	0.9819	0.9711	0.9649	0.9530	0.0000
0.8470	0.8691	0.8966	0.9263	0.9634	0.9968	1.0098	1.0109	1.0063	1.0000
	0.9912	0.9879	0.9884	0.9809	0.9763	0.9654	0.9580	0.9474	0.0000
0.8482	0.8696	0.8956	0.9240	0.9570	0.9872	0.9997	1.0015	0.9968	0.9922
	0.9833	0.9812	0.9816	0.9734	0.9685	0.9590	0.9510	0.9391	0.0000
0.8484	0.8701	0.8936	0.9198	0.9509	0.9756	0.9866	0.9900	0.9871	0.9830
	0.9743	0.9732	0.9725	0.9643	0.9594	0.9487	0.9385	0.9280	0.0000
0.8499	0.8698	0.8924	0.9166	0.9430	0.9630	0.9727	0.9780	0.9758	0.9720
	0.9646	0.9626	0.9618	0.9535	0.9494	0.9356	0.9288	0.9170	0.0000
0.8494	0.8700	0.8907	0.9103	0.9336	0.9518	0.9596	0.9640	0.9616	0.9608
	0.9529	0.9517	0.9498	0.9403	0.9354	0.9226	0.9162	0.9003	0.0000
0.8506	0.8696	0.8882	0.9060	0.9252	0.9398	0.9456	0.9496	0.9490	0.9478
	0.9409	0.9391	0.9368	0.9272	0.9219	0.9104	0.9038	0.8892	0.0000

0.8506	0.8686	0.8846	0.8998	0.9160	0.9276	0.9322	0.9358	0.9351	0.9369
	0.9278	0.9252	0.9218	0.9124	0.9071	0.8946	0.8871	0.8698	0.0000
0.8523	0.8681	0.8824	0.8954	0.9078	0.9172	0.9206	0.9228	0.9222	0.9209
	0.9142	0.9118	0.9073	0.8980	0.8902	0.8788	0.8690	0.8532	0.0000
0.8532	0.8672	0.8799	0.8896	0.8992	0.9066	0.9088	0.9106	0.9080	0.9066
	0.9004	0.8970	0.8928	0.8810	0.8754	0.8601	0.8496	0.8283	0.0000
0.8552	0.8657	0.8772	0.8844	0.8913	0.8964	0.8969	0.8974	0.8951	0.8939
	0.8876	0.8818	0.8774	0.8672	0.8598	0.8433	0.8329	0.8144	0.0000
0.8554	0.8646	0.8733	0.8786	0.8836	0.8879	0.8854	0.8854	0.8825	0.8796
	0.8718	0.8667	0.8614	0.8501	0.8429	0.8266	0.8134	0.7895	0.0000
0.8566	0.8640	0.8701	0.8731	0.8766	0.8784	0.8757	0.8736	0.8699	0.8670
	0.8576	0.8528	0.8484	0.8341	0.8266	0.8107	0.7981	0.7729	0.0000
0.8574	0.8626	0.8662	0.8674	0.8692	0.8696	0.8654	0.8630	0.8579	0.8546
	0.8452	0.8390	0.8320	0.8186	0.8111	0.7948	0.7800	0.7563	0.0000
0.8576	0.8616	0.8627	0.8621	0.8623	0.8616	0.8562	0.8518	0.8466	0.8428
	0.8320	0.8255	0.8176	0.8050	0.7956	0.7808	0.7634	0.7370	0.0000
0.8576	0.8594	0.8593	0.8568	0.8559	0.8530	0.8475	0.8418	0.8371	0.8314
	0.8196	0.8137	0.8045	0.7924	0.7822	0.7640	0.7481	0.7203	0.0000
0.8584	0.8584	0.8566	0.8526	0.8494	0.8461	0.8398	0.8332	0.8270	0.8205
	0.8088	0.8002	0.7929	0.7793	0.7688	0.7519	0.7342	0.7092	0.0000
0.8581	0.8562	0.8524	0.8481	0.8432	0.8394	0.8320	0.8238	0.8186	0.8116
	0.7997	0.7910	0.7818	0.7684	0.7561	0.7380	0.7202	0.6926	0.0000
0.8576	0.8544	0.8490	0.8428	0.8384	0.8336	0.8250	0.8159	0.8098	0.8014
	0.7884	0.7804	0.7697	0.7570	0.7441	0.7258	0.7078	0.6787	0.0000
0.8571	0.8526	0.8460	0.8388	0.8331	0.8274	0.8178	0.8083	0.8018	0.7924
	0.7801	0.7705	0.7602	0.7470	0.7382	0.7152	0.6956	0.6670	0.0000
0.8569	0.8509	0.8436	0.8351	0.8284	0.8214	0.8113	0.8017	0.7936	0.7843
	0.7719	0.7606	0.7519	0.7376	0.7336	0.7052	0.6855	0.6566	0.0000
0.8568	0.8492	0.8410	0.8311	0.8242	0.8159	0.8056	0.7953	0.7857	0.7773
	0.7638	0.7521	0.7436	0.7290	0.7150	0.6959	0.6774	0.6454	0.0000
0.8564	0.8473	0.8380	0.8269	0.8202	0.8114	0.8004	0.7890	0.7791	0.7706
	0.7561	0.7451	0.7355	0.7216	0.7074	0.6876	0.6702	0.6344	0.0000
0.8556	0.8456	0.8352	0.8233	0.8164	0.8076	0.7957	0.7837	0.7742	0.7638
	0.7494	0.7391	0.7287	0.7150	0.7006	0.6802	0.6626	0.6262	0.0000
0.8547	0.8439	0.8331	0.8206	0.8132	0.8038	0.7915	0.7796	0.7690	0.7577
	0.7434	0.7333	0.7229	0.7090	0.6946	0.6736	0.6549	0.6206	0.0000
0.8538	0.8421	0.8315	0.8185	0.8109	0.8004	0.7878	0.7759	0.7629	0.7528
	0.7378	0.7274	0.7171	0.7038	0.6896	0.6676	0.6480	0.6151	0.0000
0.8530	0.8402	0.8299	0.8169	0.8094	0.7981	0.7848	0.7720	0.7574	0.7485
	0.7328	0.7215	0.7118	0.6993	0.6848	0.6624	0.6424	0.6094	0.0000
0.8520	0.8388	0.8282	0.8161	0.8083	0.7969	0.7822	0.7684	0.7548	0.7438
	0.7289	0.7165	0.7082	0.6954	0.6798	0.6576	0.6378	0.6050	0.0000
0.8508	0.8376	0.8264	0.8159	0.8076	0.7960	0.7806	0.7664	0.7542	0.7396
	0.7257	0.7127	0.7060	0.6919	0.6749	0.6540	0.6340	0.6012	0.0000
0.8498	0.8362	0.8250	0.8150	0.8070	0.7948	0.7804	0.7654	0.7532	0.7371
	0.7230	0.7099	0.7032	0.6886	0.6711	0.6518	0.6310	0.5960	0.0000
0.8489	0.8344	0.8235	0.8136	0.8062	0.7936	0.7809	0.7646	0.7508	0.7362
	0.7204	0.7076	0.6997	0.6856	0.6686	0.6502	0.6285	0.5901	0.0000
0.8478	0.8326	0.8218	0.8126	0.8057	0.7926	0.7809	0.7637	0.7488	0.7352
	0.7183	0.7052	0.6972	0.6830	0.6667	0.6478	0.6258	0.5862	0.0000
0.8465	0.8308	0.8198	0.8124	0.8052	0.7918	0.7800	0.7628	0.7482	0.7334
	0.7167	0.7030	0.6964	0.6810	0.6650	0.6446	0.6230	0.5846	0.0000
0.8452	0.8294	0.8183	0.8120	0.8050	0.7910	0.7794	0.7620	0.7476	0.7318
	0.7156	0.7014	0.6957	0.6796	0.6636	0.6424	0.6210	0.5826	0.0000
0.8443	0.8281	0.8174	0.8112	0.8048	0.7904	0.7795	0.7614	0.7460	0.7314
	0.7148	0.7005	0.6944	0.6788	0.6629	0.6418	0.6202	0.5790	0.0000

Figure 35 (continued): BRDF file (this one is P25B).

5.6 IES Body Shadow File

This file is similar in concept to the BRDF files. I.e., it contains factors which are accessed from a 2-dimensional array based on the azimuth and declination angles of an incident light ray. In this case, however, all factors are either 0 or 1 -- 1 if the incident light ray strikes the target, 0 if the ray cannot strike the target because of the presence of the observer.

The body shadow file consists of 37 cards of 19 values each. Each card corresponds to one azimuthal plane; the first card is 0 degrees (due north); the second card is 5 deg. azimuth, etc. On each card, the first value is 0 deg. (zenith); the second value is 5 deg. declination, etc. The cards are to be read via FORTRAN FORMAT(19F2.0).

1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
1	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0
1	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0
1	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0
1	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0
1	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0
1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

column 2

Figure 36: IES Body Shadow Table

5.7 RCS Curve File

The RCS (Relative Contrast Sensitivity) curve is a function which gives the eye's sensitivity to task-background contrast as a function of task luminance. The curve is a critical component in an ESI calculation. The CEL-1 RCS file contains the task luminance values (in footlamberts) corresponding to a large range of RCS values. The RCS values begin at 1.000 and decrease in steps of 0.001 down to 0.064 -- thus, there are 937 entries (each entry is a task luminance) total in the file. The first entry is the task luminance corresponding to RCS = 1.000; the second entry is the task luminance corresponding to RCS = 0.999, etc. Each card contains 12 entries, with 6 card columns allowed for each value, so the file is read using FORTRAN FORMAT(12F6.0).

column 2

0.292	0.295	0.301	0.304	0.310	0.312	0.318	0.321	0.327	0.330	0.336	0.339
0.345	0.347	0.353	0.359	0.365	0.368	0.374	0.380	0.383	0.388	0.394	0.397
0.403	0.409	0.412	0.418	0.423	0.429	0.432	0.438	0.444	0.450	0.456	0.461
0.467	0.473	0.479	0.485	0.491	0.496	0.502	0.508	0.514	0.520	0.526	0.531
0.537	0.543	0.549	0.555	0.561	0.566	0.575	0.581	0.587	0.596	0.602	0.610
0.619	0.628	0.637	0.645	0.654	0.663	0.672	0.680	0.689	0.698	0.707	0.715
0.724	0.733	0.742	0.750	0.759	0.768	0.777	0.785	0.794	0.803	0.812	0.821
0.829	0.838	0.847	0.856	0.864	0.873	0.882	0.891	0.899	0.908	0.920	0.931
0.943	0.955	0.967	0.978	0.990	1.002	1.013	1.025	1.037	1.048	1.060	1.072
1.083	1.095	1.107	1.118	1.130	1.142	1.153	1.165	1.177	1.188	1.200	1.212
1.223	1.235	1.247	1.259	1.270	1.282	1.294	1.305	1.317	1.329	1.340	1.352
1.364	1.375	1.387	1.399	1.410	1.422	1.434	1.445	1.457	1.469	1.480	1.492
1.504	1.515	1.527	1.539	1.551	1.562	1.574	1.586	1.597	1.609	1.621	1.632
1.647	1.659	1.670	1.682	1.694	1.708	1.723	1.737	1.749	1.764	1.778	1.793
1.807	1.822	1.837	1.851	1.866	1.880	1.895	1.910	1.924	1.942	1.959	1.977
1.994	2.012	2.029	2.047	2.064	2.082	2.099	2.117	2.135	2.152	2.170	2.187
2.205	2.225	2.245	2.266	2.286	2.307	2.327	2.348	2.368	2.389	2.409	2.429
2.450	2.470	2.491	2.511	2.532	2.549	2.570	2.590	2.610	2.631	2.651	2.672
2.692	2.713	2.733	2.754	2.774	2.794	2.815	2.835	2.856	2.876	2.897	2.920
2.940	2.960	2.980	3.000	3.020	3.040	3.060	3.080	3.100	3.120	3.140	3.160
3.180	3.200	3.230	3.260	3.280	3.300	3.330	3.350	3.370	3.400	3.430	3.450
3.480	3.500	3.530	3.560	3.590	3.610	3.640	3.670	3.700	3.730	3.760	3.790
3.820	3.850	3.880	3.910	3.950	3.980	4.010	4.040	4.080	4.110	4.140	4.170
4.210	4.250	4.290	4.320	4.360	4.400	4.440	4.480	4.520	4.560	4.600	4.640
4.680	4.720	4.760	4.800	4.840	4.880	4.920	4.960	5.010	5.050	5.090	5.130
5.180	5.230	5.280	5.320	5.360	5.410	5.460	5.500	5.550	5.600	5.650	5.690
5.740	5.800	5.840	5.890	5.950	6.000	6.050	6.100	6.160	6.210	6.260	6.310
6.360	6.420	6.480	6.540	6.590	6.650	6.700	6.760	6.820	6.870	6.930	6.990
7.050	7.120	7.170	7.230	7.290	7.350	7.410	7.470	7.530	7.590	7.650	7.710
7.770	7.830	7.900	7.960	8.030	8.110	8.170	8.230	8.290	8.350	8.430	8.490
8.570	8.630	8.700	8.770	8.840	8.900	8.970	9.040	9.110	9.180	9.260	9.340
9.40	9.48	9.55	9.62	9.70	9.79	9.87	9.96	10.04	10.13	10.22	10.34
10.42	10.52	10.62	10.72	10.83	10.92	11.04	11.13	11.25	11.37	11.48	11.59
11.70	11.82	11.94	12.08	12.18	12.31	12.43	12.58	12.69	12.81	12.93	13.08

Figure 37: Tabulated RCS Curve values.

13.19	13.32	13.45	13.60	13.72	13.86	14.01	14.15	14.27	14.42	14.58	14.73
14.88	15.03	15.17	15.33	15.49	15.63	15.80	15.96	16.11	16.30	16.43	16.60
16.78	16.94	17.09	17.30	17.45	17.63	17.80	17.98	18.16	18.35	18.52	18.70
18.90	19.09	19.28	19.45	19.66	19.85	20.04	20.22	20.45	20.66	20.86	21.10
21.32	21.54	21.76	21.96	22.20	22.41	22.65	22.88	23.08	23.32	23.53	23.82
24.04	24.32	24.54	24.79	25.00	25.30	25.60	25.80	26.00	26.30	26.60	26.80
27.10	27.40	27.70	28.00	28.20	28.50	28.80	29.10	29.40	29.70	30.00	30.30
30.60	30.90	31.20	31.60	31.90	32.20	32.50	32.90	33.20	33.60	33.90	34.30
34.70	35.00	35.40	35.80	36.20	36.60	37.00	37.40	37.90	38.30	38.70	39.10
39.50	40.00	40.40	40.80	41.30	41.80	42.30	42.80	43.20	43.70	44.20	44.80
45.30	45.80	46.40	47.00	47.60	48.10	48.70	49.30	50.00	50.40	51.00	51.60
52.30	52.90	53.50	54.10	54.80	55.40	56.00	56.60	57.20	57.90	58.50	59.20
59.80	60.40	61.10	61.80	62.40	63.00	63.70	64.30	65.00	65.60	66.20	67.00
67.70	68.40	69.10	69.80	70.40	71.10	71.80	72.40	73.20	74.00	74.60	75.40
76.20	77.00	77.80	78.70	79.50	80.50	81.30	82.20	82.80	83.70	84.80	85.80
86.70	87.80	88.90	90.00	91.10	92.00	93.00	94.20	95.40	96.60	97.80	99.00
100.2	101.5	102.5	103.9	105.0	106.0	107.2	108.4	109.8	111.0	112.3	113.5
114.7	115.9	117.0	118.5	119.6	120.9	122.3	123.5	125.0	126.1	127.5	129.0
130.5	132.0	133.4	134.9	136.4	137.8	139.3	140.7	142.1	143.6	145.1	146.5
148.0	149.5	151.0	152.4	154.1	155.9	157.3	159.0	161.0	162.9	164.6	166.1
167.8	169.8	171.5	173.6	175.5	177.5	179.5	181.5	183.5	186.0	188.0	190.0
192.2	194.2	196.3	199.0	201.0	204.0	206.0	208.0	210.0	213.0	215.0	218.0
220.0	222.0	224.0	226.0	229.0	232.0	235.0	239.0	240.0	242.0	245.0	248.0
250.0	253.0	256.0	259.0	262.0	265.0	268.0	271.0	274.0	276.0	280.0	283.0
286.0	289.0	292.0	295.0	299.0	302.0	306.0	309.0	312.0	316.0	320.0	323.0
327.0	330.0	335.0	339.0	342.0	346.0	350.0	354.0	358.0	363.0	367.0	371.0
375.0	379.0	384.0	388.0	392.0	397.0	401.0	405.0	410.0	414.0	419.0	423.0
428.0	433.0	437.0	442.0	447.0	452.0	456.0	461.0	467.0	471.0	477.0	482.0
487.0	493.0	500.0	504.0	510.0	516.0	522.0	528.0	534.0	540.0	546.0	552.0
559.0	565.0	571.0	577.0	584.0	590.0	596.0	602.0	608.0	614.0	620.0	626.0
634.0	640.0	648.0	655.0	662.0	670.0	676.0	682.0	692.0	700.0	708.0	717.0
724.0	732.0	741.0	749.0	758.0	767.0	776.0	785.0	795.0	805.0	815.0	824.0
834.0	844.0	856.0	865.0	878.0	888.0	900.0	910.0	920.0	930.0	944.0	956.0
970.	982.	995.	1007.	1019.	1034.	1048.	1063.	1078.	1091.	1105.	1118.
1134.	1149.	1165.	1179.	1196.	1212.	1230.	1245.	1262.	1280.	1300.	1320.
1340.	1363.	1380.	1400.	1420.	1440.	1460.	1484.	1510.	1534.	1559.	1581.
1608.	1635.	1664.	1692.	1721.	1750.	1780.	1810.	1835.	1868.	1900.	1938.
1979.	2022.	2062.	2110.	2153.	2206.	2264.	2327.	2390.	2458.	2550.	2606.
2767.	2920.										

Figure 37 (continued): Tabulated RCS Curve values.

Section VI

Executing the CEL-1 Programs from a Remote Batch Terminal

6.1 Control Cards

This section shows the card deck structure required to submit the CEL-1 programs to NOS via a remote batch terminal. Submission of the jobs via an interactive terminal is covered in Section VI.

In the discussion to follow the symbolism

<data deck>

means the cards containing the alphabetic and numeric data which are read in by the CEL-1 programs themselves. The data deck for the CEL-1 main program is described in detail in Sections II and III. The input data decks for the auxiliary file maintenance programs CCMP and OBMP are described in Section IV. The remaining cards are called "NOS Control Cards" -- they are instructions to the NOS system itself. The "job stream" is the deck of cards obtained by combining the NOS control cards with the input data deck. Here is what the job streams should look like:

6.2 Job Stream for CEL-1 Main Program

```
JOB,<jobname>,P4,T500.
USER(<username>,<password>,<machine>)
GET.CELPROC/UN=S4696GS
CALL,CELPROC,P.
789 (end of record card)

        <data deck>

6789 (end of file card)
```

6.3 Job Stream for Auxiliary Program OBMP

```
JOB,<jobname>,P4,T10.
USER(<username>,<password>,<machine>)
ATTACH,OBMPB/UN=S4696GS.
OBMPB.
```

```
789 (end of record card)

        <data deck>

6789 (end of file card)
```

6.4 Job Stream for Auxiliary Program CCMP

```
JOB,<jobname>,P4,T10.
USER(<username>,<password>,<machine>)
ATTACH.CCMPB/UN=S4696GS.
CCMPB.
789 (end of record card)

        <data deck>

6789 (end of file card)
```

In the above job streams, each card must be reproduced exactly as shown, except for the entries enclosed in the <> angle brackets, for which the substitutions are:

<jobname> is 1 to 7 alphanumeric characters which label the user's output.

<username> is the user's NOS account name.

<password> is the user's NOS account password.

<machine> identifies the NOS machine the user is running on (KWA or KBT).

In addition, the 789 (end of record card) means a card which has rows 7, 8, and 9 punched on column 1. The 6789 (end of file card) has rows 6, 7, 8, and 9 punched on column 1.

SECTION VII

CEL-1 Interactive Capabilities

7.1 The Preprocessor

When using a remote batch (RJE) terminal. the CEL-1 user must punch his input data deck onto cards and combine this data deck with NOS control cards in order to construct the complete job stream. He then submits this job stream through the remote batch terminal. The interactive user who chooses not to utilize the preprocessor follows essentially the same steps. In creating the input data deck, the interactive user hits virtually the same keystrokes as he would in punching cards; the difference is that he is keying in a permanent file to saved -- he accomplishes this by using the NOS text editing facilities.

The virtue of the preprocessor program CEL1FE (FE for "front-end") is that the user creates the data deck by answering a series of questions. Hence he does not need to be acquainted with the NOS text editing procedures. Once the data deck file has been saved (either by using CEL1FE or by using the NOS text editor), the job is submitted by running the interactive program CEL1II.

7.2 The Interactive Interface

The CEL-1 interactive interface program. CEL1II. uses a question-and-answer sequence to construct the NOS control cards; this means that the interactive user need not be acquainted with the meanings of the NOS control cards. When the question-and-answer session is completed, CEL1II will submit the job to NOS for execution in the batch world. Either CEL-1 itself or the database maintenance programs CCMP and OBMP may be executed via CEL1II.

The remainder of this section shows console sessions for submitting CEL-1 jobs to NOS for execution. Note that the input data deck files which are created interactively must be named as follows:

Program	Data Deck Filename
CEL-1	CEL1DD
OBMP	OBMPDD
CCMP	CCMPDD

In the console session examples to follow, user key-ins are either underlined or encircled.

7.3 Creating the CEL-1 Data Deck using the Preprocessor

(user logs on)

```
GET,CEL1FE/UN=S4696GS
READY.
-CEL1FE


        -CEL-1 PREPROCESSOR-


-ENTER 5 LINES OF TEXT ID FOR JOB (MAX 80 CHARS PER LINE)
 ? EXAMPLE 1 -  40' X 30' X 10' ROOM
 ? REFLECTANCES: (WALLS=50%. FLOOR=20%. CEILING=80%)
 ? SIX 2-LAMP FLUORESCENT LUMINAIRES  (PHOTOMETRIC FILE 'HB57'),
 ?    3150 LUMENS PER LAMP
 ? NO FURNITURE OR DAYLIGHT.  CALCULATIONS:  ESI. HORIZ FC. VCP


-ENTER ROOM DIMENSIONS. DISCRETIZATION #'S IN PAIRS:
 -WIDTH (E-W)   ? 40 20
 -LENGTH (N-S)  ? 30 15
 -HEIGHT        ? 10 5


-ENTER SURFACE REFLECTANCES IN THIS ORDER:
   WEST WALL, NORTH WALL, EAST WALL, SOUTH WALL, FLOOR, CEILING
 ? .5 .5 .5 .5 .2 .8


-HOW MANY ROOM SURFACE INSERTS ?0


-DO YOU WANT TO USE DAYLIGHT (Y/N) ?N


-HOW MANY OBSTRUCTIONS ARE PRESENT IN THE ROOM ?0


-DO YOU WANT TO COMPUTE ESI RATINGS (Y/N) ?N


-ARE TASK LOCATIONS ON A RECTANGULAR GRID (Y/N) ?Y


-ENTER DETAILS FOR GRID OF TASK LOCATIONS:
 - # COLUMNS (MAX 21) ? 20
 - # ROWS (MAX 21) ? 15
 - LEFTMOST X-COORDINATE ? 1
 - RIGHTMOST X-COORDINATE ? 39
 - LOWEST Y-COORDINATE ? 1
 - HIGHEST Y-COORDINATE ? 29
```

```
 - HEIGHT ABOVE FLOOR ? 2.5

-HOW MANY VIEWING DIRECTIONS ? 4

-ENTER 4 VIEWING DIRECTION ANGLES ? 0 90 180 -90

-WHICH METRICS DO YOU WANT TO PRINT OUT:
 -HORIZ FC (NO SHADOW) (Y/N) ?Y
 -HORIZ FC (WITH SHADOW) (Y/N) ?N
 -ESI (Y/N) ?Y
 -VCP (Y/N) ?Y
 -BACKGROUND LUMINANCE (Y/N) ?N
 -TASK LUMINANCE (Y/N) ?N
 -CRF (Y/N) ?N
 -LEF (Y/N) ?N
 -PLOT HORIZ FC(NO SHADOW) (Y/N) ?N
 -PLOT ESI (Y/N) ?N
 -PLOT VCP (Y/N) ?N

-WHAT IS NAME OF FILE WITH BDGD LUMINANCE BRDF FACTORS ? P25B

-WHAT IS NAME OF FILE WITH TASK LUMINANCE BRDF FACTORS ? P25T

-HOW MANY DIFFERENT TYPES OF LUMINAIRES DO YOU INTEND TO USE ? 1

-FOR LUMINAIRE TYPE #  1:
 -WHAT IS PHOTOMETRIC FILE NAME ? HB57
 -TOTAL INITIAL LAMP LUMENS ? 6300
 -LIGHT LOSS FACTOR ? .82
 -WIDTH OF LUMINOUS OPENING ? 1.833
 -LENGTH OF LUMINOUS OPENING ? 3.833
 -HEIGHT OF LUMINAIRE ? 0.5

 -HOW MANY LUMINAIRES THIS TYPE ? 6

 -FOR EACH LUMINAIRE ENTER X.Y.Z COORDINATE AFTER '(X.Y.Z)'
  PROMPT; ENTER BEARING, TILT. CANT ANGLES AFTER 'ORIENT' PROMPT.

 -LUM #  1:
  (X.Y.Z) ? 10 10 9.5
  ORIENT  ? 0 0 0

 -LUM #  2:
  (X.Y.Z) ? 20 10 9.5
  ORIENT  ? 0 0 0

 -LUM #  3:
  (X.Y.Z) ? 30 10 9.5
  ORIENT  ? 0 0 0

 -LUM #  4:
```

```
 (X.Y.Z) ? 10 20 9.5
 ORIENT  ? 0 0 0

-LUM #  5:
 (X.Y.Z) ? 20 20 9.5
 ORIENT  ? 0 0 0

-LUM #  6:
 (X.Y.Z) ? 30 20 9.5
 ORIENT  ? 0 0 0
```

```
*** YOUR DATA DECK IS SAVED AS FILE 'CEL1DD'; THE FILE HAS LINE
    NUMBERS.  YOU MAY LIST THE FILE AND/OR CHANGE IT USING THE
    NOS LINE EDITOR.  TO SUBMIT THE DECK FOR EXECUTION. KEY IN:

                  GET.CEL1II/UN=S4696GS
                  -CEL1II
```

7.4 Creating the CEL-1 Data Deck using the NOS Line Editor

(user logs on)

```
NEW,CEL1DD
READY.
100 EXAMPLE 1 -  40' X 30' X 10' ROOM
110 REFLECTANCES:  (WALLS = 50%. FLOOR = 20%. CEILING = 80%)
120 SIX 2-LAMP FLUORESCENT LUMINAIRES  (PHOTOMETRIC FILE 'HB57')
130    3150 LUMENS PER LAMP.
140 NO FURNITURE OR DAYLIGHT.  CALCULATIONS:  ESI. HORIZ FC. VCP
150   1  1
160 40 20  30 15  10 5
170 .5 .5 .5 .5 .2 .8
180 TASK=UNKNOWN
190  20 15  1 39  1 29  2.5  4.0
200   4
210 0 90 180 -90
220 LUMINAIRES
230 HB57
240 6300.  .82
250 1.833 3.833 0.5  92
260 0 0 0 0
270   6
280 1  10 10 9.5  0 0 0
290 2  20 10 9.5  0 0 0
300 3  30 10 9.5  0 0 0
310 4  10 20 9.5  0 0 0
320 5  20 20 9.5  0 0 0
330 6  30 20 9.5  0 0 0
340 CALCULATE
350 ESI HOR VCP
360 P25B
370 P25T
SAVE
READY.
```

7.5 Creating the OBMP Data Deck using the NOS Line Editor

(user logs on)

```
NEW,OBMPDD
READY.
100 DELETE
110  2
120 ADD
130  1  1.75 1.25 5  .15 .15 .15 .15 .15 .15
140 ADD
150  1  5.0 3.0 2.5  .2 .2 .2 .2 .2 .45
160 ADD
170  1  8 0.33 6  .35 .35 .35 .35 .35 .35
180 PRINT
190 STOP
SAVE
READY.
```

The data deck for the cloud database maintenance program CCMP is created in entirely analogous fashion; its filename must be CCMPDD.

7.6 Submitting the Job to NOS for Execution

(user logs on, then creates the data deck file using the NOS Line Editor. The CEL-1 data deck file CEL1DD may balso be created using the preprocessor CEL1FE)

```
GET,CEL1II/UN=S4696GS
-CEL1II


          -- CEL-1 INTERACTIVE INTERFACE --

-ENTER ID OF PROGRAM YOU WANT TO RUN:
  1 = CEL-1
  2 = OBMP
  3 = CCMP   ?1

-HAVE YOU SAVED THE DATA DECK AS FILE 'CEL1DD' (Y/N) ?Y

-ENTER PRIORITY FOR JOB (1.2.3.4, OR 6) ?4

-LOCATION CODES ARE:
  F  NAVFAC
  L  LANTDIV
  S  SOUTHDIV
  P  PACDIV
  W  WESTDIV
  N  NORTHDIV
  H  CEL, PORT HUENEME
  C  CHESDIV
-ENTER YOUR LOCATION CODE ?H

-ENTER YOUR FIRST NAME (MAX 10 CHARS) ? BILL

-ENTER YOUR LAST NAME (MAX 20 CHARS) ? BRACKETT

-ENTER CODE FOR DISPOSITION OF OUTPUT:
  1  ROUTE TO YOUR REMOTE BATCH TERMINAL
  2  PRINT AT CENTRAL SITE. MAIL TO YOU
  3  SAVE FOR SUBSEQUENT RETRIEVAL AT INTERACTIVE TERMINAL
    ?1

-DOES FILE 'CEL1DD' HAVE LINE NUMBERS (Y/N) ?Y

-DO YOU WANT TO SUBMIT THIS JOB (Y/N) ?Y


*** JOB HAS BEEN SUBMITTED ***
```

7.7 Listing CEL-1 Output at the Interactive Terminal

When the user directs that his output be saved for subsequent retrieval at his interactive terminal, the output will be saved on one of three files:

```
CEL1OUT  - from program CEL1
OBMPOUT  - from program OBMP
CCMPOUT  - from program CCMP
```

It is possible simply to list these files by using, for example, the command sequence

```
GET,CEL1OUT
LIST,F=CEL1OUT
```

The objection to this is that the listing will not be formatted properly (spacing between lines will not be right) and trailing blanks will be printed and thus increase the time required to obtain the listing.

The preferred method is to execute the program OUTLIST via these commands:

```
GET,OUTLIST/UN=S4696GS
-OUTLIST
```

The program will then prompt the user for the name of the file to be listed; the user should respond with one of the names CEL1OUT. OBMPOUT. OR CCMPOUT. When the listing is complete. remember to purge the output file to avoid paying permanent file storage charges on it.

APPENDIX A -- Prototype Input Data Deck

```
ROOM
 line 1 of text ID
 line 2 of text ID
 line 3 of text ID
 line 4 of text ID
 line 5 of text ID
INSERTS
 # of inserts
 surface #. reflectance. x-limits, y-limits, z-limits
     .
     .
 surface #. reflectance. x-limits, y-limits, z-limits
TASK
RATING
 # locations, height. IES or Navy rating
 x, y, view direction
     .
     .
 x, y, view direction

UNKNOWN
 # columns, # rows, x-limits, y-limits,
       height, eye height for VCP
 # viewing directions
 viewing directions

KNOWN
 # locations, height
 x, y, view direction
     .
     .
 x, y, view direction
SENSORS
 # interior sensors
 x, y, z, orientation
     .
     .
 x, y, z, orientation
FENESTRATION
WINDOW
 glazing, transmittance
 width, height
 # locations
 surface, x, y, z
     .
     .
 surface, x, y, z
SHADE
 transmittance, depth
```

```
DRAPE
 transm., left pull, right pull
BLINDS
 type, thickness, width, spacing, angle, reflec.
SHELF
 depth, protrusion, reflectance
BARRIERS
 distance, limit 1, limit 2, protrusion, reflec.
 distance, limit 1, limit 2, protrusion, reflec.
 distance, limit 1, limit 2, protrusion, reflec.
 distance, limit 1, limit 2, protrusion, reflec.
CLERESTORY
 width, length, depth, glazing
 transm. 1, transm. 2, transm. 3, transm. 4, transm 5.
 # locations
 x, y, z
     .
     .
 x, y, z
SAWTOOTH
 width, length, height, glazing, direction
 transmittance, vertical reflectance, sloping reflectance
 # locations
 x, y, z
     .
     .
 x, y, z
SKYLIGHT
 width, length, depth, glazing
 transm. 1, transm. 2, transm. 3, transm. 4, transm. 5
 # locations
 x, y, z
     .
     .
x, y, z
BUILDING
 # buildings
 x, y, z, E-W dimension, N-S dimension, height
     .
     .
 x, y, z, E-W dimension, N-S dimension, height
 west reflec., north reflec., east reflec., south reflec.,
         roof reflec.
 angle from true north
     .
     .
     .
GROUND
 ground reflectance
 # ground inserts
 insert reflec., x-limits, y-limits, z
     .
     .
 insert reflec., x-limits, y-limits, z
```

```
FURNITURE
 # obstructions in room
 database ID, x, y, z, orientation angle
     .
     .
 database ID. x. y. z. orientation angle
PROFILE
 latitude, longitude, time zone meridian, station ID
 daylight savings time map
 occupancy factors
ANALYSIS
 latitude, longitude, time zone meridian, station ID
 daylight savings time map
 # times
 month. day. time of day
     .
     .
 month, day, time of day
LUMINAIRES
 photometric file name
 initial lumens, light loss factor
 width, length, height, watts
 minimum gain, quadratic coefficients (watts vs. gain)
 # luminaires
 sequence #, x, y, z, bearing, tilt, cant
     .
     .
 sequence #, x, y, z, bearing, tilt, cant
DIMMING
 control method
 control criterion value(s)
 control indicator
 control target area definition (# cols, # rows, x-limits.
                 y-limits, z)
 # luminaires always off
 list of luminaires always off
     .
     .
 list of luminaires always off
 # of luminaires to be dimmed
 list of luminaires to be dimmed
     .
     .
 list of luminaires to be dimmed
DESIGN
 photometric file name
 initial lumens, light loss factor
 width, length, height
 bearing, tilt, cant
 minimum illuminance, minimum ESI, average illuminance
 # columns, # rows, x-limits, y-limits, z
 mask line 1
     .
     .
```

```
 mask line n
CALCULATE
 keyword 1, keyword 2,  ...  , keyword n
 background BRDF filename
 target BRDF filename
```

APPENDIX B -- Photometric Database

A photometric file (disc file) for CEL-1 use may be given any name which conforms to the CYBERNET file-naming requirements. Thus, a user may key in and save any photometric data he chooses. However, recall that if CEL-1 does not find the referenced file in the user's catalog, then the catalog of user # S4696GS is searched for the file.

A database of photometric files is stored in user # S4696GS -- this database consists of the photometric data shown in Figure 9-12 of the 1981 IES LIGHTING HANDBOOK (Reference Volume). There are 49 photometric files, and they are named by appending the corresponding luminaire number to the characters HB (for "handbook"). For example, HB9 is luminaire # 9 from Fig. 9-12; HB43 is luminaire # 43 from Fig. 9-12.

APPENDIX C -- Interfacing CEL-1 and BLAST

The BLAST thermodynamics analysis computer program accepts as inputs some of the information which is input to and computed by CEL-1. These inputs to BLAST include:

1. Locations of room surfaces.
2. Room Occupancy Schedule
3. Lighting Schedule (hourly fraction of total watts consumption)
4. Building dimensions and orientations.
5. Window locations and dimensions.

When the CEL-1 user requests it (via the TDY keyword in the CEL-1 input data deck), as many of these items are printed out as possible. They are printed in a form which is acceptable to BLAST. Where BLAST requires user-supplied names, arbitrary names are supplied by CEL-1. For example. the schedule of lighting for the month of March is named MARCH LTGSKED.

The following points must be emphasized:

1. This output is meant as an aid to the BLAST user. It will never constitute complete input to BLAST.

2. The BLAST user must integrate the information printed by CEL-1 with other parameters required by BLAST. For example, CEL-1 can handle only one room at a time and knows nothing about any construction materials used in the building.

3. The user is, of course, free to adjust the CEL-1 terminology. For example, all BLAST library entries are defined as TEMPORARY by CEL-1. The user may wish to change to DEFINE or REDEFINE.

APPENDIX D -- Load Data Sheets

ROOM block (always included):

ROOM ____________________________________

____
text ID line 1

____
text ID line 2

____
text ID line 3

____
text ID line 4

____
text ID line 5

____
input units output units (1=English, 2=Metric)

____
room dimensions, discretizations (in order, E-W, N-S, height)

____
room reflectances (west wall, north wall, east wall, south wall, floor, ceiling)

INSERTS block (include only if inserts are present):

INSERTS

Number of inserts

surface # reflect. x-low x-high y-low y-high z-low z-high

(repeat above card for each insert)

TASK block (select one of the sub-blocks RATING, UNKNOWN, or KNOWN):

TASK

RATING

locations height above floor IES/Navy option

x-coord. y-coord. primary view direction

(repeat above card for each task location)

TASK

UNKNOWN

columns # rows x-left x-right y-bootom y-top z z(VCP)

viewing directions

viewing directions (1 to 4)

TASK

KNOWN

\# locations height above floor

x-coord. y-coord. viewing direction

(repeat above card for each task location)

SENSORS block (include only if sensors are present and you are using daylight calculations):

SENSORS

\# of interior sensors

x-coord. y-coord. z-coord. orientation (5 or 6)

(repeat card above for each interior sensor)

\# of exterior sensors

x-coord. y-coord. z-coord orientation (1 - 6)

(repeat above card for each exterior sensor)

FENESTRATION block (included when and only when performing daylight calculations):

FENESTRATION ________________________________

WINDOW ________________________________

____
glazing (1=clear, 2=opaque)   transmittance

____
width   height

____
locations

____
Surface #   x-coord.   y-coord.   z-coord.

(repeat above card for each window location)

include once for each different window type

SHADE ________________________________

____
transmittance   depth below top of window

include only if shades are present

DRAPE ________________________________

____
transmittance   dist. from left   dist. from right

include only if drapes are present

BLINDS ________________________________

____
type   thickness   width   spacing   angle, reflectance

include only if blinds are present

SHELF ______________________________

include only if light shelf is present

depth protrusion reflectance

BARRIERS ______________________________

include only if one or more barriers are present on the window type in question

distance limit 1 limit 2 protrusion, reflectance

distance limit 1 limit 2 protrusion, reflectance

distance limit 1 limit 2 protrusion reflectance

distance limit 1 limit 2 protrusion reflectance

CLERESTORY ______________________________

include once for each different clerestory type

width length depth glazing

transmittances (5 values)

locations

x-coord. y-coord. z-coord.

(repeat above card for each location)

SAWTOOTH

include once for each different sawtooth type

width length height glazing direction of glaze

transmittance sloping reflect. vertical reflectance

locations

x-coord. y-coord. z-coord.

(repeat above card for each location)

SKYLIGHT

include once for each different skylight type

width length depth glazing

transmittances (5 values)

locations

x-coord. y-coord. z-coord.

(repeat above card for each location)

BUILDING

this block always included for daylight calculations

buildings

x y z E-W dim. N-S dim. height

repeat for each building

reflectances (5 values)

angular displacement from true north

<u>GROUND</u>

This sub-block always included for daylight calculations

___

ground reflectance

___

ground inserts

___

reflect.   x-left   x-right   y-bottom   y-top   z-coord.

(repeat above card for each ground insert)

FURNITURE Block:

FURNITURE ______________________

____
obstructions

____
database ID x y z orientation

(repeat above card for each different obstruction)

PROFILE Block: (included only when computing energy profile)

PROFILE ______________________

____
latitude longitude long. at center of time zone station ID

____
daylight savings time map

____
occupancy factors

ANALYSIS Block:

ANALYSIS ______________________

____
latitude longitude long. at center of time zone station ID

____
daylight savings time map

____
times (maximum 15)

____
month day time of day

(repeat above card for each time)

LUMINAIRES Block:

LUMINAIRES

photometric file name

initial lumens   light loss factor

width   length   height   watts

minimum gain   ratic coefficients (watts vs. gain)

luminaires

sequence #   x   y   z   bearing   tilt   cant

(repeat card above for each luminaire location)

DIMMING Block:

DIMMING

control method (1, 2, or 3)

control criterion values

control indicators (one 1, four 0's)

cols   # rows   x-left   x-right   y-bottom   y-top   z-coord.
(above card defines a control target area)

luminaires always off

list of luminaires always off (max 10 sequence #'s)

(repeat ca[illegible] until all luminaires to be off have been [illegible]ted)

\# of luminaires in the dimming group

list of luminaires to be dimmed (max 10 sequence #'s)

(repeat card above until all luminaires to be controlled have been enumerated)

DESIGN Block: (used for design synthesizer only)

DESIGN

photometric file name

initial lumens light loss factor

width length height

bearing tilt cant

min. illuminance min. ESI avg. illuminance

\# cols # rows x-left x-right y-bottom y-top z-coord.

mask card

(there are as many mask cards as rows of luminaires)

CALCULATE Block (always required):

CALCULATE

____

list of keywords

____

background BRDF filename

____

target BRDF filename